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OVERLAND FLOW TREATMENT OF MUNICIPAL WASTEWATER IN FLORIDA

by

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16. ABSTRACT

Overland flow has been demonstrated as a feasible method of treating municipal wastewater in most climates throughout the United States. However, optimum design criteria for year round operation in warm humid climates where primary and secondary pretreated wastewater have not been completed. Treatment performance of four overland flow plots sodded with native turf grasses were evaluated using both primary and secondary municipal wastewater in northwestern Florida. The prime objective of thie study was to optimize loading of both effluents to exceed secondary wastewater discharge standards during year round operation. The project was successful and has been used as a pilot scale study for development of a number of other full scale overland flow systems in Florida.

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FOREWORD

EPA is charged by Congress to protect the Nation's land, air, and water systems. Under a mandate of national environmental laws focused on air and water quality, solid waste management and the control of toxic substances, pesticides, noise, and radiation, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life. In partial response to these mandates, the Robert S. Kerr Environmental Research Laboratory, Ada, Oklahoma, is charged with the mission to manage research programs: to investigate the nature, transport, fate, and management of pollutants in ground water; to develop and demonstrate technologies for treating wastewater with soils and other natural systems; to control pollution from irrigated crop and animal production agricultural activities; and to develop and demonstrate cost-effective land treatment systems for the environmentally safe disposal of solid and hazardous wastes.

The purpose of this project was to demonstrate the feasibility of using one of the three major land treatment processes, overland flow, to treat both primary and secondary pre-treated sewage in a region of high rainfall and mild climate. The U.S. Environmental Protection Agency had been encouraging the use of natural treatment systems and this project was initiated to use currently available design criteria for this system. The continued monitoring resulted in improved design, and operation of overland flow systems for small communities in warm climates.

Clinton W. Hall

Clinton W. Hall, Director
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ABSTRACT

The physical and biological processes of overland flow treatment of municipal wastewater were studied. A 5 ha spray field, two 12.2 x 30.5m plots and two 12.2 x 35.0m plots were employed along with a activated sludge treatment plant to determine relations of efficiency, residence time and mass transfer with application rate for secondary and primary wastewaters. Mathematical models were presented and used to describe relations between dispersion, mass transfer, treatment efficiency and application rate.

It was shown that for the application rates of the plots used, the

1. Residence time was described by a power function of application rate,

2. Mass transfer was diffusion limited rather than reaction limited,

3. Dispersion was not adversely affected by increasing flow depth,

4. Plots were not loaded to a point where efficiency changed with application rate, and

5. No seasonal change in treatment efficiency for TSS, BOD and TKN was observed.

Also, the field study indicated that

1. For most parameters except phosphorus, the runoff enhanced the quality of the receiving waters, and

2. Overland flow treatment provided an excellent polishing unit for conventional treatment plant effluent.

This report was submitted in fulfillment of Cooperative Agreement CR 807914 by the University of Florida under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period October 1980 to January 1984, and work was completed as of March 1, 1984.

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ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

BOD -- biological oxygen demand
COD -- chemical oxygen demand
DI -- deionized water
DO -- dissolved oxygen
EC -- electrical conductivity
Org N -- organic nitrogen
Ortho P -- orthophosphate
TKN -- total kjedahl nitrogen
TN -- total nitrogen
TSS -- total suspended solids
TP -- total phosphorus
TURB -- turbidity

SYMBOLS

C -- concentration of chemical species
D -- dispersion coefficient
d -- mean depth
L -- plot length
Q -- flow rate
q -- flow rate/width
s -- slope
t -- time
$\bar{t}$ -- mean residence time
U -- mean velocity
W -- plot width
x -- distance down slope

Subscripts

d -- downstream
i -- i th time or sample
o -- input
r -- runoff
u -- upstream

ABBREVIATIONS AND SYMBOLS (cont'd)

Greek symbols

α	-- $-\ln C/C_0$
β	-- $(\sqrt{1+\gamma}-1)\,U/2D$
γ	-- $4kD/U^2$
Σ	-- summation
σ^2	-- variance of tracer curves

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SECTION 1

INTRODUCTION

Although much work has been done in the area of land application of municipal wastewater, very little data is available concerning the actual mechanisms involved in the treatment process. Mainly, the relationships between the hydrologic characteristics of the system and treatment efficiency are sketchy at best.

The major objectives of this project were to evaluate not only the feasibility of overland flow systems in a warm humid climate in the U.S. for year round operation and to obtain a better understanding of the design parameters with respect to transport processes as well as physical characteristics of the overland flow field. Also, a secondary objective was to study the effect of the overland flow field runoff on the receiving waters.

In order to achieve these objectives, it was necessary to locate a site in which much flexibility was available with respect to design, implementation and operation of the project. Also necessary was the availability of a site with low soil permeability, an existing wastewater treatment process to utilize primary wastewater as well as holding pond effluent, and a reasonable travelling distance for personnel to collect samples and maintain the project.

It is believed that the earliest applications of overland flow treatment of municipal wastewater occurred at Werribee, Australia in 1897 for the city of Melbourne (McPherson 1978, Kirby 1971). An estimation of service life of an overland flow system can be had from the Werribee system which is still in operation today. Overland flow treatment of municipal wastewater in Florida, though not currently widely used, appears to be a very feasible and promising alternative especially to the smaller communities (Overman 1982).

Martel et al. (1980) proposed the following empirical equation

$$\bar{t} = \frac{0.078\ x}{s^{1/3}\ q} \qquad (1)$$

where $\bar{t}$ = peak detention time, hr
x = distance down the slope, meters
s = slope grade
q = average flow rate per unit width, $m^3/hr/m$.

However, a more precise estimation of residence time can be obtained from Levenspiel (1972) in which the mean residence time equals the centroid of a tracer concentration curve. From Clark, Viessman and Hammer (1977) the relation between residence time and loading for trickling filters is similar to that for overland flow.

Overman, Chu and Leseman (1976) suggest that the mass transport equation for one dimensional dispersed flow in a packed bed reactor is applicable to the transport processes of overland flow. The solution of this equation is of the same form as that proposed by Smith (1982), Abernathy (1983) and Peters, Lee and Bates (1981) which states that treatment efficiency, C/C_0 is an exponential function of distance down the slope from point of application. From the solution a value for the mass transfer coefficient can be obtained directly. Metcalf and Eddy (1979) indicate that for small velocities the relation between mass transfer coefficient and velocity is linear for trickling filters.

The mentioned literature for the most part indicates that overland flow systems have not been loaded high enough to clarify the relation between treatment efficiency and residence time. A recent exception is the work of Wightman et al. (1983).

SECTION 2

CONCLUSIONS

SPRAY FIELD

Measurements were made of runoff water from a 5 ha spray field. Results showed that the field served as an excellent polishing unit for the treatment plant. Average runoff concentrations were: TSS = 5.6, BOD = 3.7 and TKN = 1.8 mg/l. Stream measurements showed that runoff had little impact on stream DO, TSS, BOD and TKN. There was an increase in total P in the stream.

PRETREATMENT

Both secondary and primary wastewater were applied to experimental plots. For secondary wastewater reduction of TSS, BOD and TKN on the plots was limited by the presence of algae from the holding pond. A detention time just adequate to achieve flow equalization, would be desirable. An alternative would be level control of the pump from a small holding faclity. With primary wastewater, the factor limiting reduction was detention time. A longer slope length, say 50 m, would be preferable.

Water was applied to plots 5 hr/day, 7 days/week. This caused a shift in vegetation on one plot receivng primary waste water, from bahia grass to pennywort during the second year. While excellent treatment occurs during the summer, pennywort dies off during winter and may provide inadequate treatment. Allowing 2 or 3 days down time each week would enhance weed control.

Maintenance mowing, with no crop removal, appeared to work quite well. Nitrogen removal appeared to have more to do with bacterial conversions than crop uptake.

SEASONAL EFFECT

Data for the plots were used to evaluate treatment efficiency throughout the year. Graphical presentation of data for TSS, BOD and TKN showed no apparent effect of season of the year on efficiency. It should be pointed out that during the period of this study, no significant ice formation was noted on the plots. Such formation could upset flow control on the field and thereby reduce treatment efficiency.

RATE PROCESSES

Experiments were conducted on one of the plots receiving primary wastewater to determine various rate processes. Salt spike measurements showed that mean residence time decreased with pumping rate, while average flow velocity and depth increased. Both hydrodynamic mixing (dispersion) and mass transfer coeficients increased with velocity. Mass transfer increased approximately linearly with velocity, so that reductions of TSS, BOD and organic N were essentially independent of pumping rate. It may be concluded that mass transfer was diffusion limited, rather than reaction limited. Since reduction down the slope has been shown to be exponential, it follows that reduction efficiency is more sensitive to slope length than pumping rate.

FLOW CONTROL

Many projects on overland flow treatment have experienced difficulty with flow control. This one was no exception. Fan nozzles were first used, but were plagued with clogging by small fish and turtles from the holding pond. A new distribution system was designed which used a 10 cm PVC horizontal line with 1.9 cm adjustable drop tubes on 120 cm centers. This system worked quite well with both primary and secondary wastewater. With primary, drainage was required biweekly to flush through accumulated solids. With secondary, the system was virtually maintenance free. The system also minimized pumping energy.

Flow control downslope was enhanced by construction of small berms on 120 cm centers. These did not interfere with mowing which was done up and down slope with a Gravely tractor equipped with high floatation tires and a flail mower.

SECTION 3

RECOMMENDATIONS

Studies should be conducted at greater hydraulic loading rates to more nearly approach reaction limit. In most work to date, mass transfer was diffusion limited. Data on mean residence time, pumping rate and input/output concentrations of TSS, BOD, DO, and nitrogen species should be collected.

More data is needed with secondary wastewater low in algae, since the efficiency of overland flow as a polishing unit appears to be limited by algae. Shorter detention time before field application should be provided.

More information on phase-in time after a down period is needed for warm, humid climates. It appears to be in the order of one to three days based on the rate of decline in turbidity of runoff after start-up.

Field measurements on slopes less than two percent are needed. Smaller slopes would reduce cut and fill costs and reduce erosion potential in areas with sandy topsoils. Success of such a system would greatly depend on uniformity of grade and flow control.

Overland flow should be given strong consideration as a treatment alternative in warm climates due to its consistent efficiency throughout the year.

SECTION 4

EXPERIMENTAL PROCEDURES

SITE DESCRIPTION

Field experiments were conducted at the wastewater treatment plant in Gretna, Florida. The site is located on U.S. Highway 90 about 300 kilometers (180 miles) west of Gainesville (see Figure 1). A schematic of the treatment plant and related area is shown in Figure 2. The plant uses the activated sludge process. It has a design capacity of 450 m^3/day (120,000 gpd), with an average daily flow of 225 m^3/day (60,000 gpd). Water flows into a holding pond, through an irrigation system and onto a 5 ha spray field. The field has an average slope of 2 percent and consists of a Plummer sand (USDA, 1961), which is poorly drained. Permeability of the upper horizon exceeds 25 cm/hr. Low permeability of the subsoil restricts downward percolation of water. Quoting the soil survey report, describing Plummer sand:

> The surface layer is 2 to 5 inches thick and is predominantly grayish in color. In a few areas it is very dark gray, and in some small areas it is almost white. The subsoil ranges from gray to white in color and from fine sand to sand in texture. It is slightly mottled with yellow to yellowish brown in places. The depth to moderately fine textured material normally ranges from 42 inches to more than 72 inches. A few areas have a subsoil of fine sandy loam or light fine sandy clay loam beginning at depths of 30 to 42 inches. Included with this soil are small areas that have a fine sand surface soil.
>
> This soil has a high water table at or near the surface most of the time. It is very low in organic matter and natural fertility. It has a low available moisture-holding capacity. Permeability is rapid, and the cation-exchange capacity is very low. Plant nutrients leach rapidly.

On-site borings (Ardaman and Associates, 1975) yield generalized results shown in Table 1. Average rainfall for the area is 135 cm/year (54 inches/year).

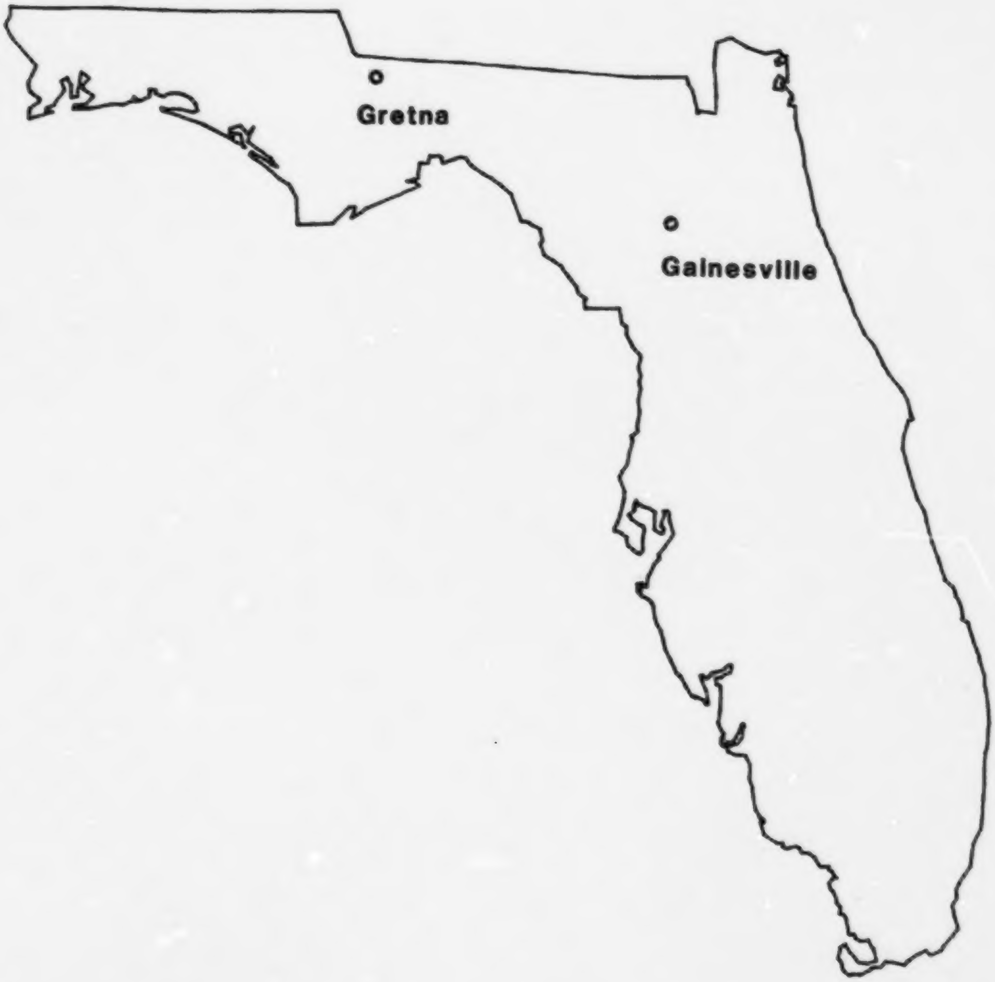

Figure 1. Site Location.

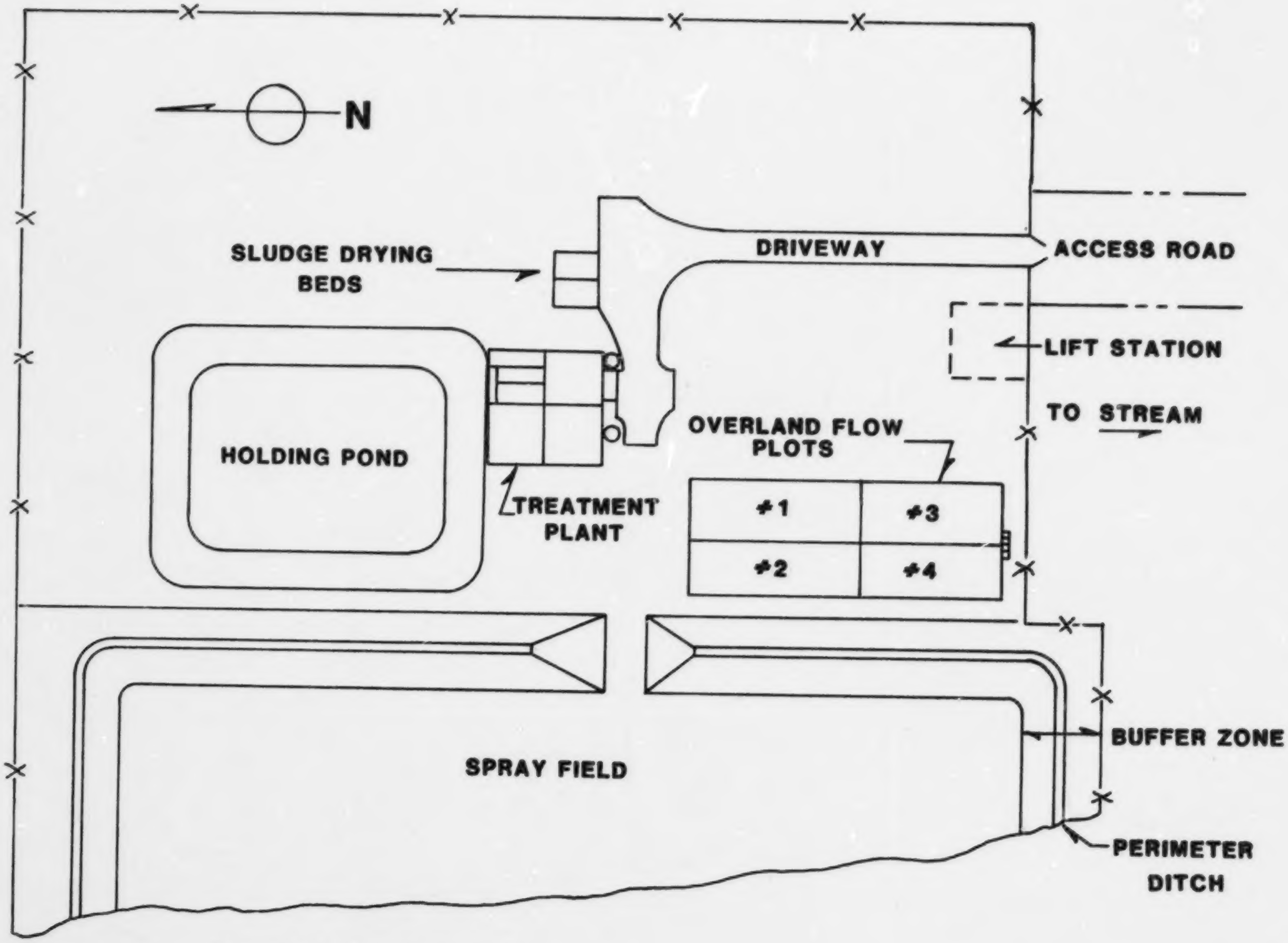

Figure 2. Site Description.

Field and Stream Study

The spray irrigation system was designed as a slow-rate irrigation unit with no discharge. Due to factors of rainfall, soil characteristics and slope, runoff did accumulate at the lower end of the field. Eventually it overtopped the berm constructed around the field. Even though water was distributed over the field through impact sprinklers, some erosion and channeling occurred before the coastal bermudagrass became established. Following discussions with the consulting enineers, staff of the Florida Department of Environmental Regulation and the Gretna Town Council, a brief sampling program of runoff and stream quality was initiated in 1981.

Table 1. Generalized Soil Description,*

Depth, m	Soil Description
0.0 - 0.6	Tan to brown medium to fine slightly clayey sand in a very loose condition.
0.6 - 1.8	Tan to brown fine sandy clay in a soft condition.
1.8 - 4.2	Grey to tan moderately plastic sandy clays in a stiff condition.
4.2 - 6.0	Yellow-tan slightly clayey sand varying from very hard to dense.

* Source: Ardaman and Associates, 1975.

An expanded program was developed to evaluate the potential for overland flow treatment in Florida. As a part of this effort a detailed evaluation of the treatment plant, spray field and the receiving stream was conducted during the period 4/82-8/82. Grab samples were collected of raw wastewater holding pond, runoff, upstream and downstream. The program was designed to evaluate treatment efficiency in the treatment plant and across the field, as well as the impact of runoff on the receiving stream.

Plot Studies

Four experimental plots were constructed to evaluate the effect of (1) vegetation, (2) preapplication treatment (3) loading rate on treatment efficiency and (4) seasonal change in treatment efficiency. The layout is shown in Figure 2.

Initially a distribution system was installed using fan nozzles. Submersible pumps (open impeller) were installed in the holding pond, one for each plot. Flow was regulated with gate valves. Each pump was controlled by an automatic timer. Nozzles were spaced 120 cm (4 ft.) apart at the upper end of each plot. In April, 1981 plots were graded to 1.7 percent slope. Small berms were constructed down the slope on 120 cm centers to facilitate flow control. Vegetation was established in May, 1981 as shown in Table 2. Bahia and bermuda were seeded, while St. Augustine was sodded. Preliminary loading was used during the summer of 1981 to establish vegetation. Full irrigation began in September, 1981, and followed a schedule 5 hours/day and 7 days/week. Operation was from 8 a.m. til 1 p.m. daily. Runoff from each plot was collected at the bottom and center of each plot through a 7.5 cm (3 in.) invert. From there it was routed through a trapezoidal flume, into a common sump and back to the lift station of the plant.

Table 2. Vegetation for Plot Studies

Plot	Vegetation
1 and 2	Bahiagrass *Paspalum notatum* Flugge
3	Common bermudagrass *Cynodon dactylon* L. Pers.
4	St. Augustine *Stenotaphrum secundatum (Walt.) Kuntze*

Due to clogging by small fish from the holding pond, a new distribution system was installed in October, 1981. Distribution lines of 10 cm (4 in.) PVC were mounted across the upper end of each plot. Drop tubes of 1.9 cm (3/4 in.) PVC were mounted on a 120 cm (4 ft.) spacing. Details of the drop tubes are shown in Figure 3. These were made adjustable by way of neoprene compression fittings to provide flow equalization. An access port was drilled above each drop tube to facilitate inspection and cleaning.

The pumping system for secondary wastewater was also redesigned. Water was pumped from the pond into a metal tank with overflow back to the pond. The tank was divided with a wire screen. Some of the water passed across the screen, through a submersible pump and onto plots 2 and 3. This eliminated the clogging problem.

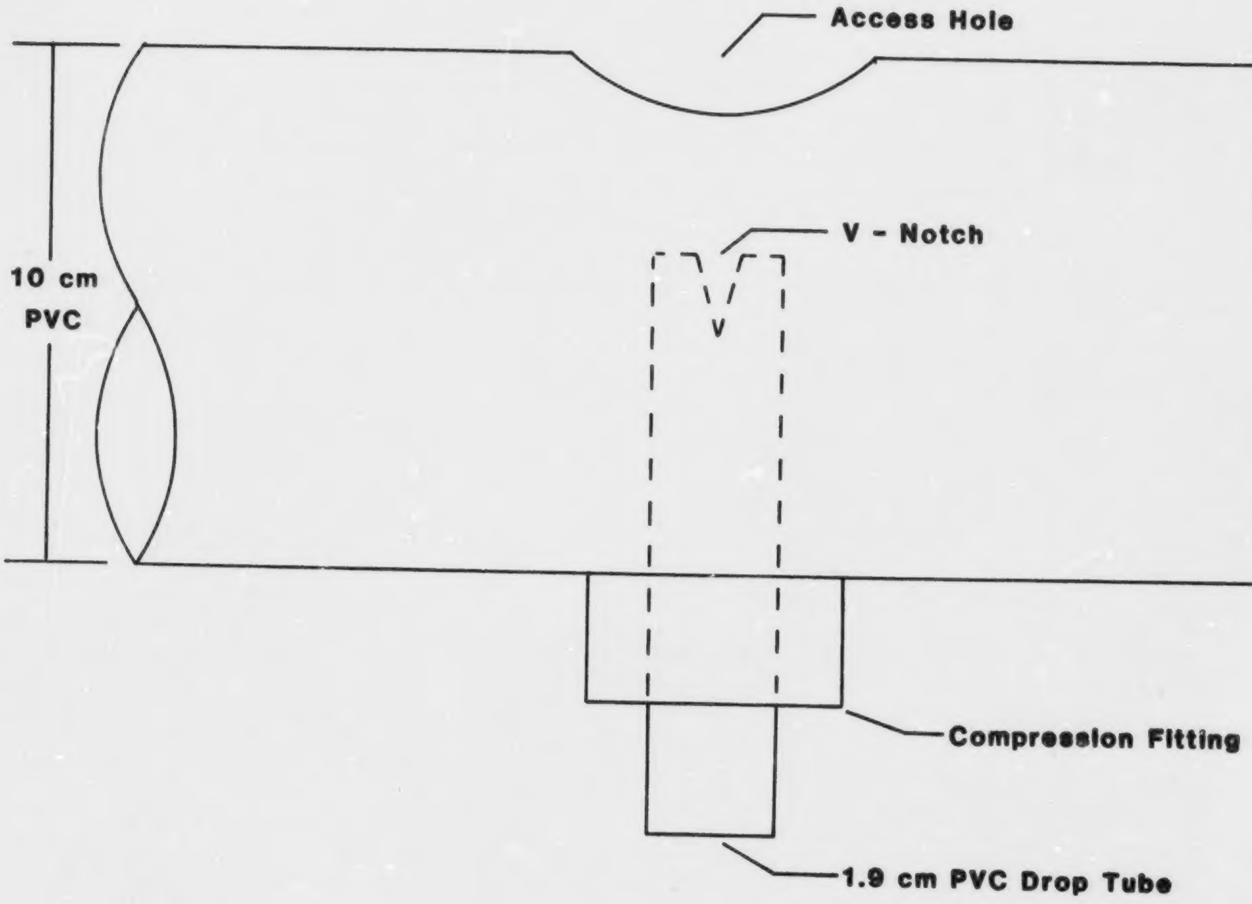

Figure 3. Details of Drop Tubes.

A system was developed for application of primary wastewater to plots 1 and 4. A wire basket strainer was mounted in the degritter tank. An open impeller submersible pump was mounted in the basket to pump raw sewage to a clarifier tank (approximately 1 hour detention time). A portion of the overflow from this tank passed through a Tuthill Model 30A process pump, equipped with variable speed motor, to each plot. All three pumps were placed on timers for automatic control.

To enhance flow control across the plots, small berms were constructed up and down slope on 120 cm (4 ft.) centers in each plot. This greatly enhanced flow distribution.

Vegetation on the plots was maintained with a Gravely Model 5000 tractor and flail mower. The tractor was equipped with turf tires for maximum floatation and minimum damage to the sod. Vegetation was not removed, but allowed to decompose on the plots.

Characteristics of the plot study with secondary wastewater are shown in Table 3. The rates shown were used in both 1982 and 1983 for plots 2 and 3. During the 4th quarter of 1982 and 1st quarter of 1983, primary wastewater was applied at a pumping rate of 68 l/min (18 gpm) for a loading rate of 30 cm/week (12 in./week) for plot 1 and 39 cm/week (15 in./week) for plot 4. During the remainder of 1983, various pumping rates were used on 1 and 4 as a part of the residence time studies.

Table 3. Plot Loading with Secondary Wastewater.

Plot	Width m	Length m	Pumping Rate l/min	Pumping Rate gpm	Loading* Rate cm/week	Loading* Rate in/week
1	12.2	37.8	49	13	22	8.8
2	12.2	37.8	49	13	22	8.8
3	12.2	30.5	49	13	28	11
4	12.2	30.5	49	13	28	11

* Water applied 5 hours/day, 7 days/week.

SAMPLING TECHNIQUES

All sampling consisted of grab samples. Since the site was 300 kilometers (180 miles) from the University of Florida, it was impractical to utilize automatic samplers. Samples were generally collected around noon, after flow had been in progress for several hours, and while flow was in progress. Raw sewage was collected from the influent line to the plant, with the lift station in the on phase. Pond water was collected from one of the distribution lines, either to the field or to a plot. All intake lines were adjacent to each other in the pond. Runoff was collected at the overflow pipe from the field. The upstream samples were collected above the culvert at the access road to the plant. Downstream samples were collected above the culvert at U.S. 90. Both stream samples were from flowing regions. The stream flowed through a swamp downhill from the spray field. Primary wastewater was collected from the overflow of the clarifier tank. Runoff from each plot was collected at the outfall of each flume.

Dissolved oxygen was measured with a YSI Model 58 portable unit. Observations were made until a stable reading was obtained. The unit had automatic temperature compensation, so that manual compensation was not required.

SECTION 5

RESULTS AND DISCUSSION

GENERAL COMMENTS

The initial focus of the project between the University of Florida and the Town of Gretna was to evaluate treatment efficiency of the overall system, including plant and field. Results of a brief sampling period in 1981 revealed high quality runoff from the field. However, the consistency of performance and the relative contributions of plant and field were not apparent from these results. The scope of the project was expanded to include performance of both the plant and the field, as well as plot studies with secondary and primary wastewater. Funds were obtained from EPA to evaluate treatment efficiency of overland flow in a warm humid climate and with the stipulation that a Quality Assurance Program would be included. From the outset of the project, an attempt has been made to quantify system performance and various rate processes. In this section, results of the field and stream study is given first. Attention is then directed to the plot study. Finally, quality assurance data are discussed.

FIELD AND STREAM STUDY

Wastewater was pumped daily from the holding pond through impact sprinklers onto a 5 ha field with coastal bermudagrass. Slope of the field was 2.0 percent. The field was not graded to a uniform slope, as it was designed as an irrigation field. The warm season was selected for sampling, as it appeared that the greatest impact on stream quality and dissolved oxygen would be observed. Runoff from the field flowed to Telogia Creek, which exhibited year round flow. Upstream samples were collected at the access road to the treatment plant. Downstream samples were collected at highway US 90, approximately 400 m below the upstream point and approximately 200 m below confluence of runoff and stream flow. Grab samples were collected of raw sewage, holding pond, runoff, upstream, and downstream. The sampling period was April 14 through August 10 of 1982.

Results of the study are presented in Tables A-1 through A-11. From these results treatment efficiencies of the plant and field may be calculated as well as impact of runoff on the stream.

Performance of Plant and Field

Values of several parameters during the sampling period are shown in the next several graphs. Note that all of these (except total P) are on logarithmic scales. TSS (Figure 4), Turbidity (Figure 5), BOD (Figure 6), and TKN (Figure 7) all show large relative decreases from raw to pond and from pond to runoff. COD (Figure 8) is reduced greatly in the plant, but little on the field. Total P (Figure 9) is reduced some in both the plant and across the field. Average values for all parameters and sample points during the study period are shown in Table 4. In particular, average values and standard deviations in the runoff were: TSS = 5.6 ± 2.6, BOD = 2.7 ± 1.9, TKN = 1.8 ± 0.4, and NH_4-N = 0.4 ± 0.4. mg/l.

System performance is also summarized in Table 5. The ratios Pond/Raw indicate performance of the mechanical plant, Runoff/Pond of the field and Runoff/Raw of overall system. For example, Pond/Raw = 0.088 for BOD shows treatment efficiency of the plant of 91 percent. Runoff/Pond = 0.22 represents a 78 percent reduction of BOD in wastewater applied to the field. Runoff/Raw = 0.020 gives an overall efficiency of BOD removal of 98 percent. Overall reductions during this period were: TSS = 95, BOD = 98, TKN = 94 and TN = 94 percent. The spray field clearly serves as an excellent polishing unit for the treatment plant.

Since the treatment plant removed 81 percent of the influent TN, nitrogen loading to field was relatively low (TN = 5.8 mg/l). This level provided adequate nitrogen to maintain the coastal bermudagrass, but was low enough to avoid harvest of the grass. Maintenance mowing one or two times each year was adequate for weed control and without damage to the turf. At higher levels of nitrogen it is usually desirable to harvest the grass to maintain integrity of the sod.

There did not appear to be significant net loss of water on the field by evapotranspiration. Average chloride concentrations in pond and runoff were 171 and 178 mg/l, respectively, for the sample period. None of the samples were collected either during or immediately following rainfall. Due to soil characteristics, it appears that deep percolation was also negligible.

Impact on the Stream

Chloride data were used to estimate the fraction of downstream flow derived from the field. Assuming that

$$Q_d = Q_u + Q_r \qquad (2)$$

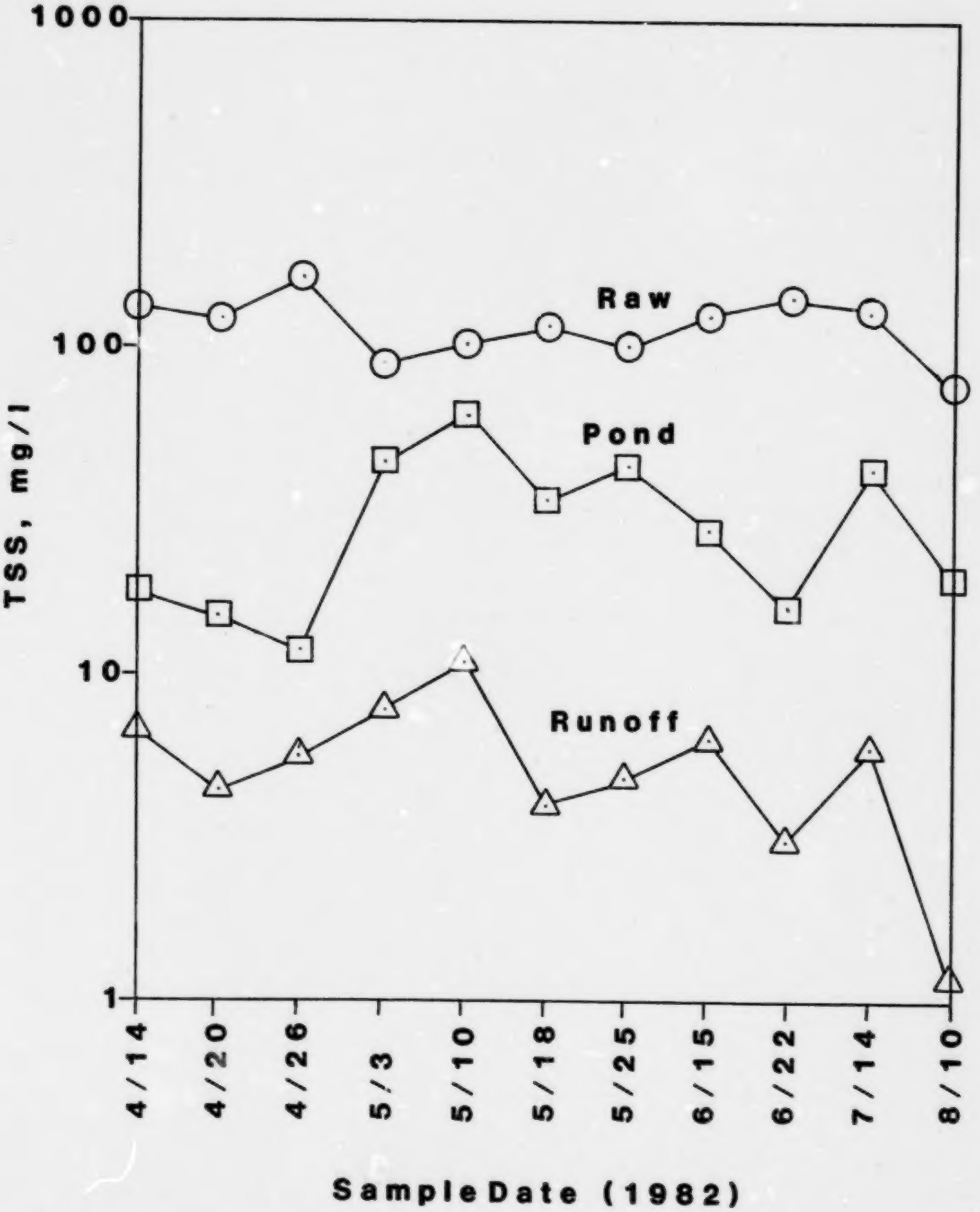

Figure 4. Total Suspended Solids Results For Field Study.

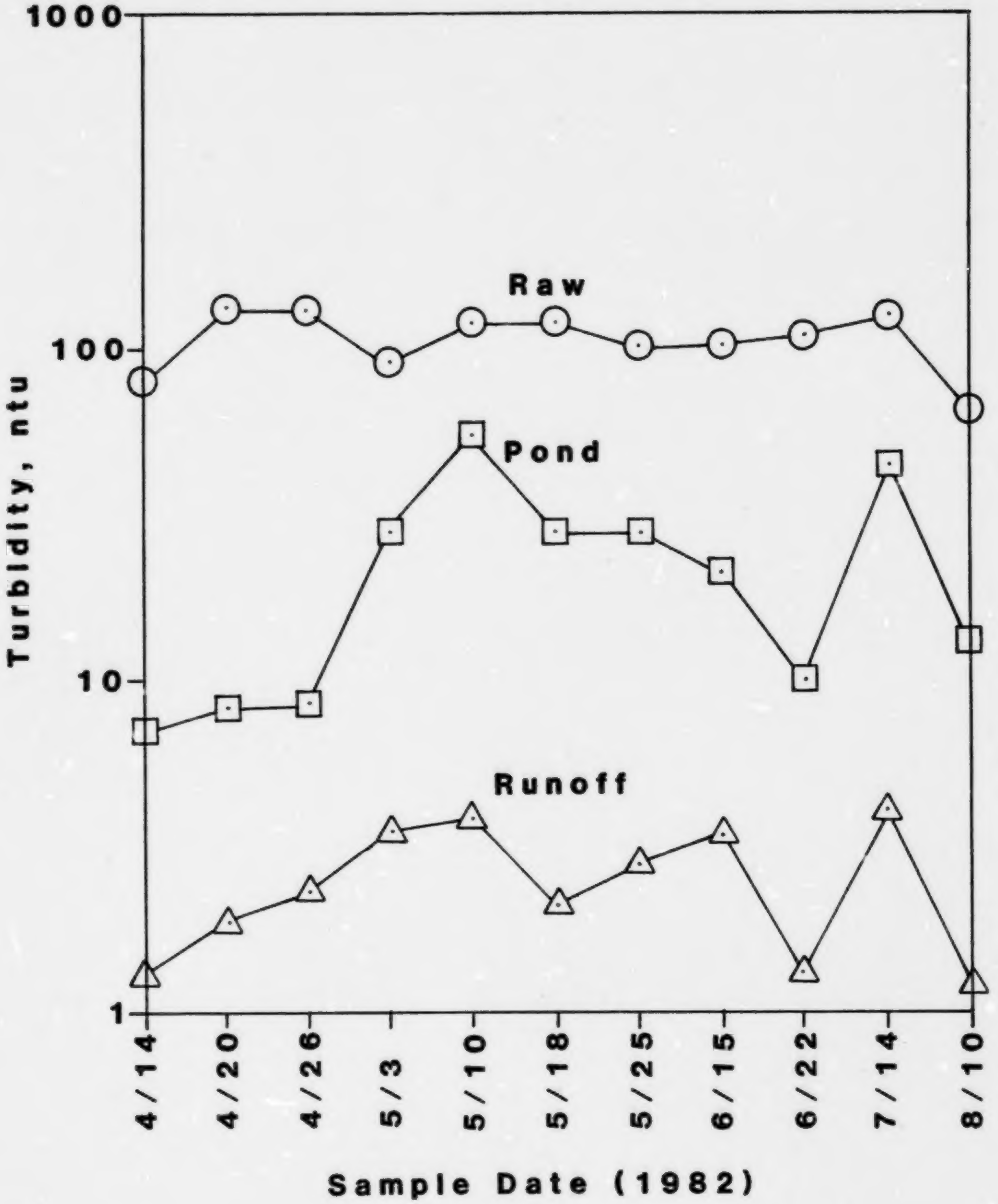

Figure 5. Turbidity Results for Field Study.

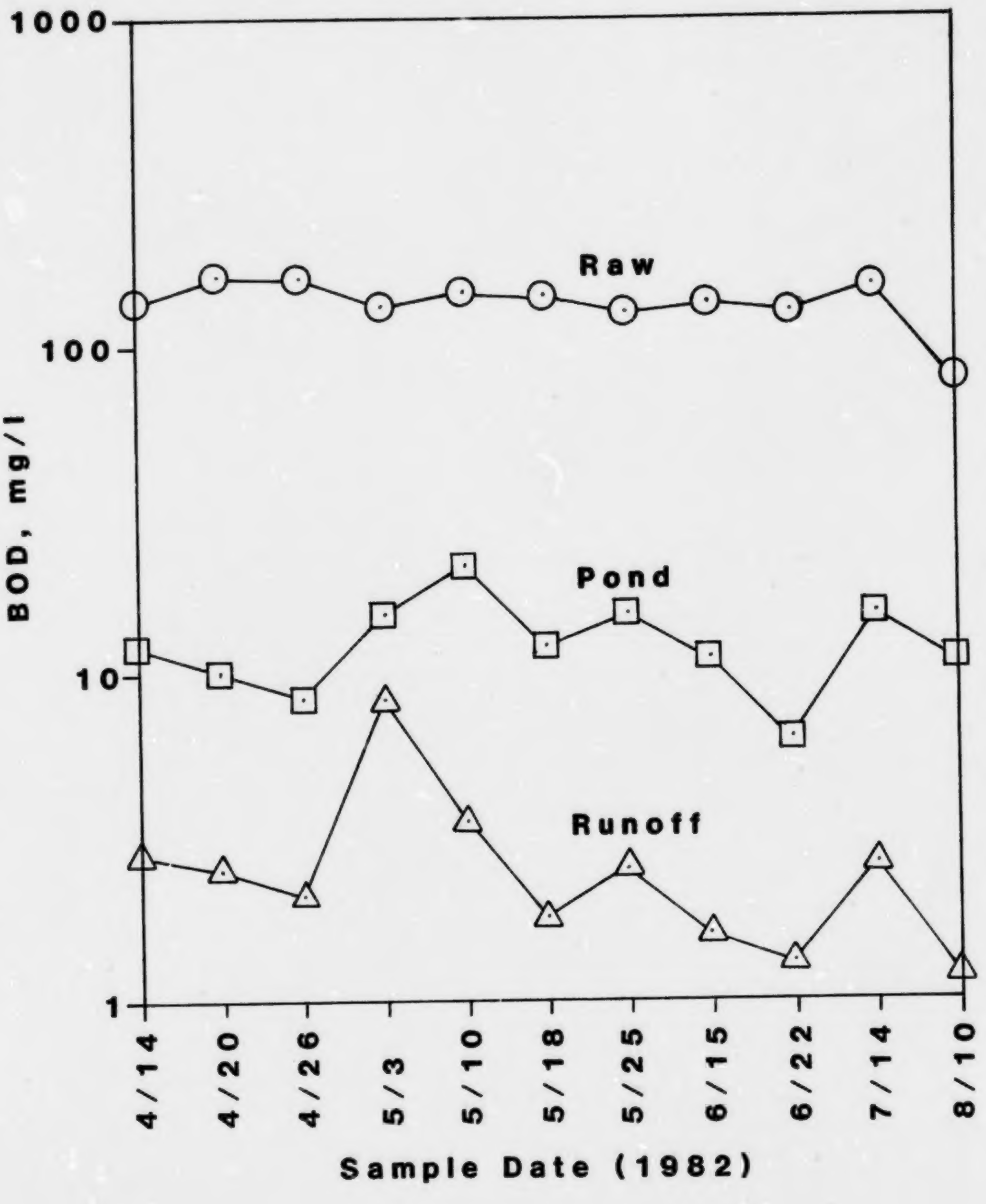

Figure 6. BOD Results for Field Study.

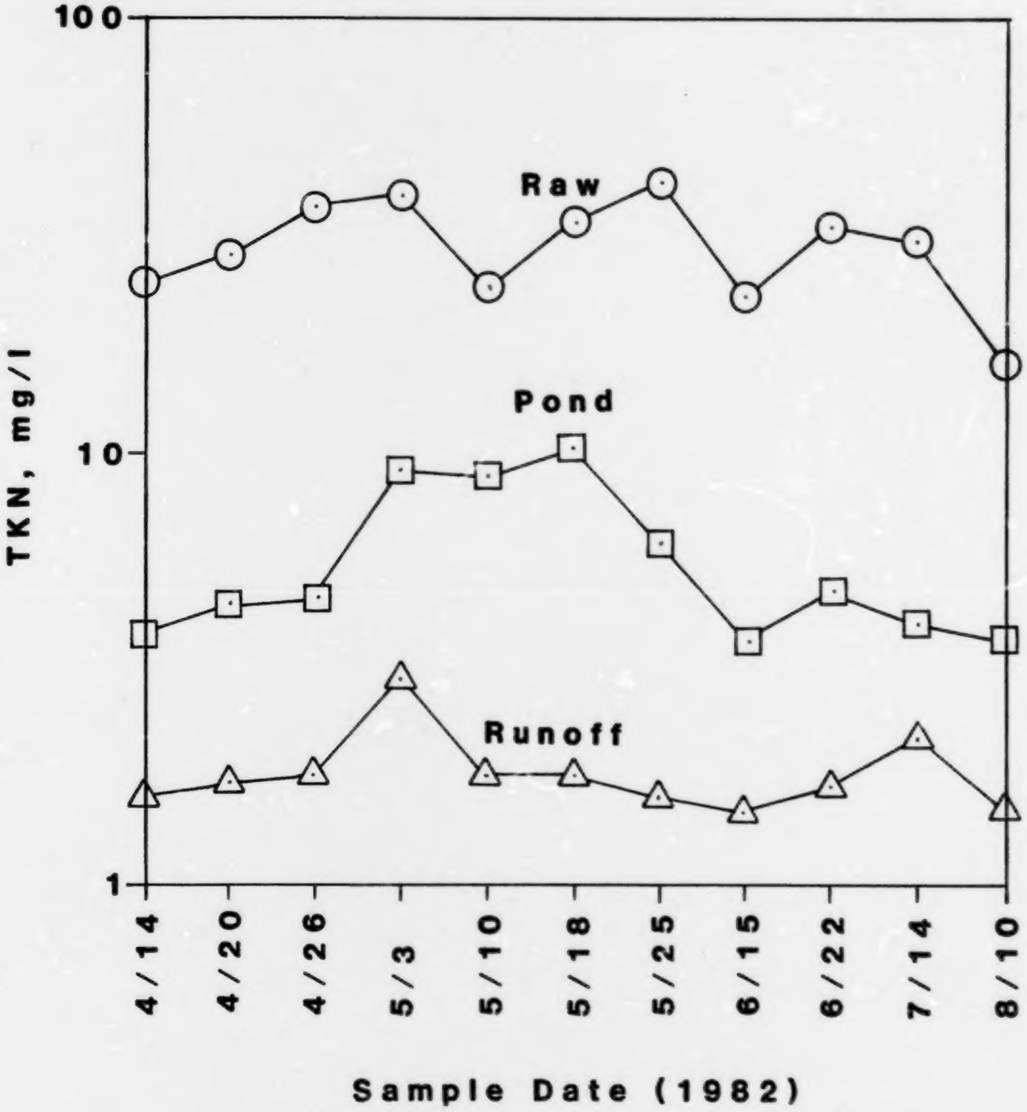

Figure 7. TKN Results for Field Study.

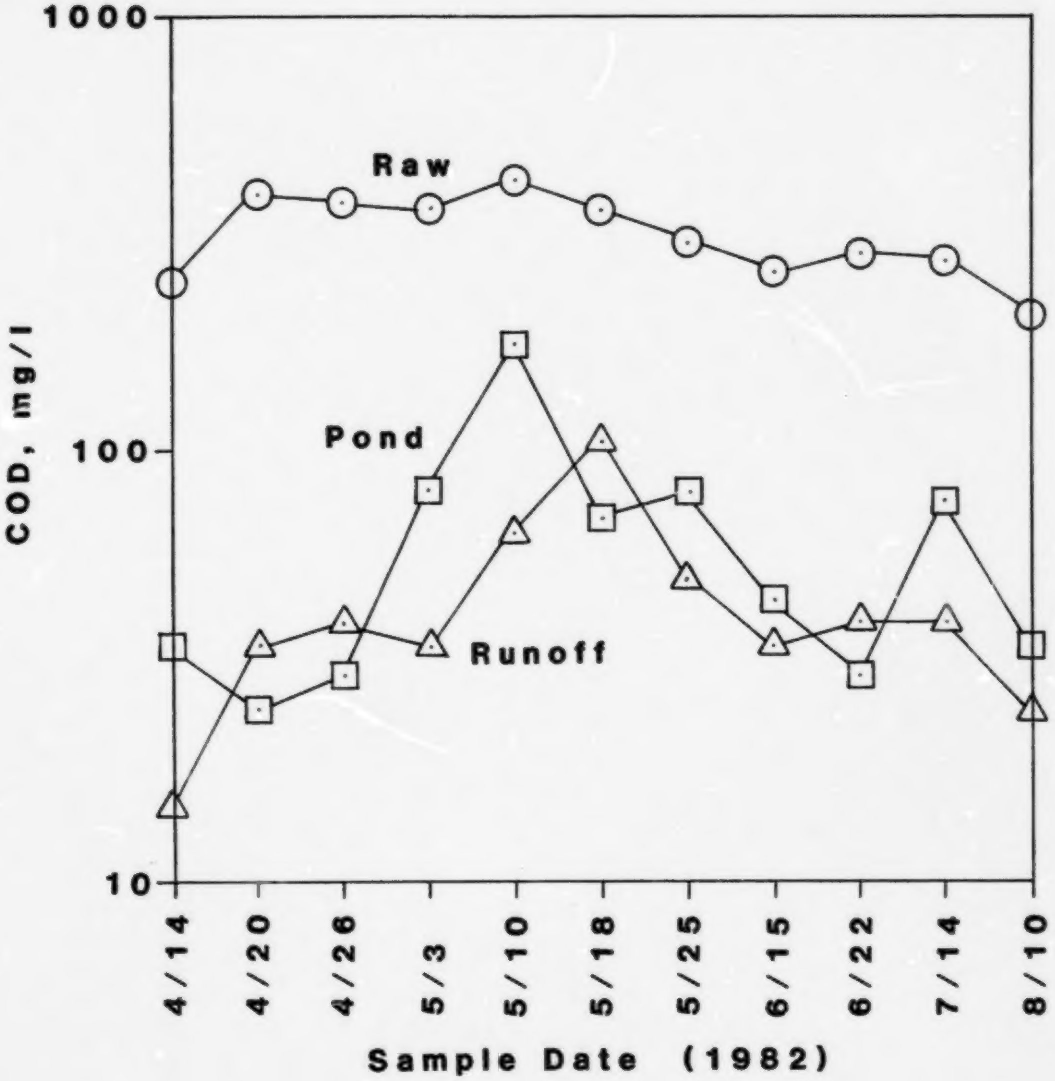

Figure 8. COD Results for Field Study.

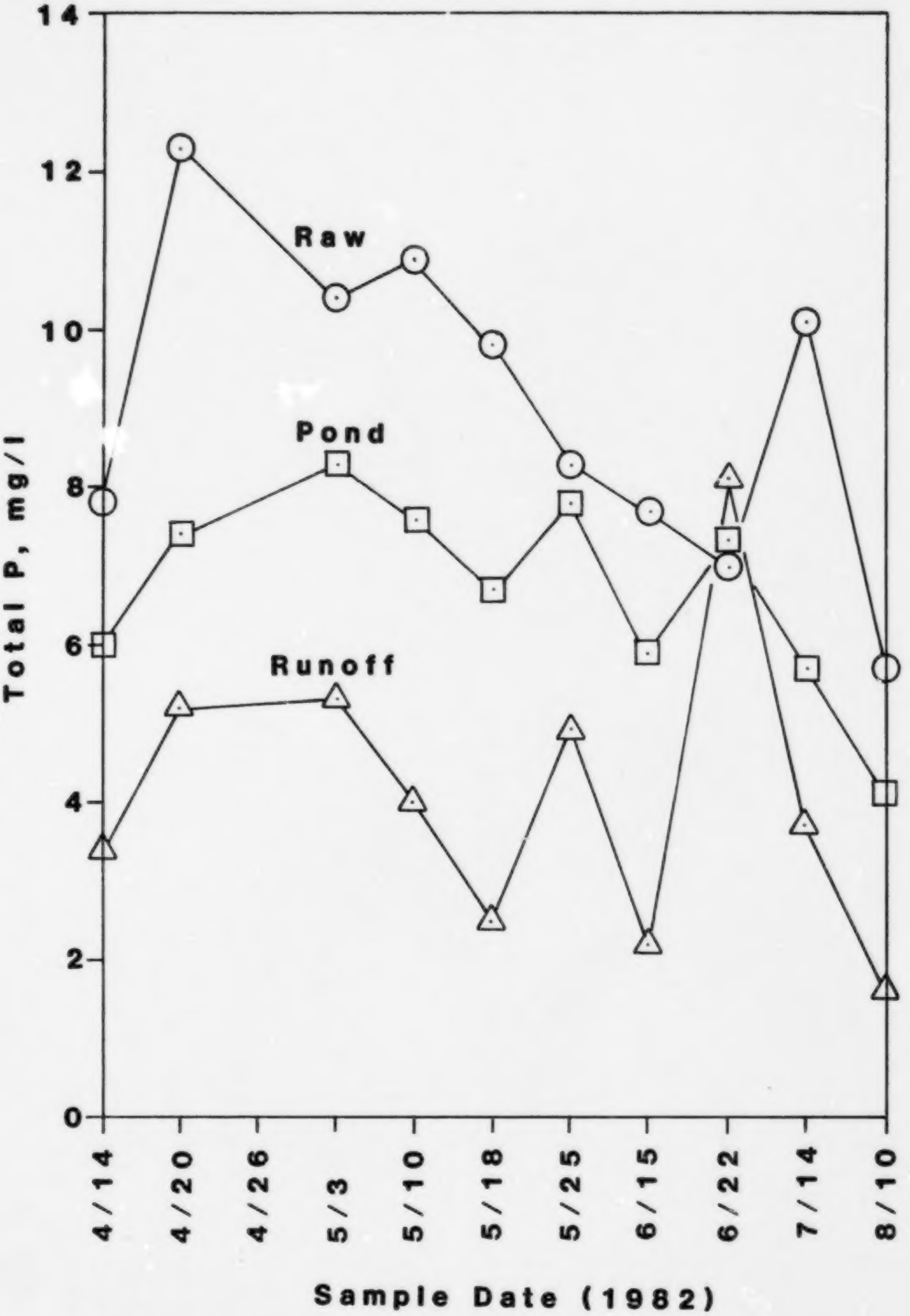

Figure 9. Total Phosphorus Results for Field Study.

Table 4. Average Values For Field Study

Parameter	Raw	Pond	Runoff	Upstream	Downstream
pH	7.5	8.4	7.5	6.1	6.3
EC umho/cm	1105.	968.	942.	78.	178.
Cl mg/l	170.	171.	178.	6.	31.
Turbidity ntu	108.	23.	2.5	2.5	4.1
BOD mg/l	136.	12.	2.7	1.4	1.3
COD mg/l	300.	65.	45.	20.	20.
NO_3-N mg/l	0.1	0.4	0.1	0.8	0.5
Org-N mg/l	10.8	3.1	1.4	0.8	0.8
NH_4-N mg/l	19.7	2.3	0.4	0.1	0.2
TKN-N mg/l	30.5	5.4	1.8	0.9	1.0
TN mg/l	30.6	5.8	1.9	1.7	1.5
Ortho-P mg/l	6.0	5.2	3.8	0.06	0.45
Total-P mg/l	9.0	6.7	4.1	0.15	0.54
TSS mg/l	120.	30.	5.6	0.8	2.0

Study Period: 4/14/82-8/10/82.

Table 5. System Performance During Field Study

Parameter	$\frac{\text{Pond}}{\text{Raw}}$	$\frac{\text{Runoff}}{\text{Pond}}$	$\frac{\text{Runoff}}{\text{Raw}}$
Turbidity	0.21	0.11	0.023
BOD	0.088	0.22	0.020
COD	0.22	0.69	0.15
Org N	0.29	0.45	0.13
TKN	0.18	0.33	0.059
TN	0.19	0.33	0.062
TP	0.74	0.61	0.46
TSS	0.25	0.19	0.047

Study Period: 4/14/82-8/10/82.

where Q_d = downstream flow rate

Q_u = upstream flow rate

Q_r = runoff flow rate

and,

$$C_d Q_d = C_u Q_u + C_r Q_r \tag{3}$$

where C_d = downstream chloride concentration

C_u = upstream chloride concentration

C_r = runoff chloride concentration

It follows that the fraction of downstream flow derived from runoff is given by

$$\frac{Q_r}{Q_d} = \frac{C_d - C_u}{C_r - C_u} \tag{4}$$

These estimates are shown in Table 6. While there are fluctuations during the period due to antecedent storm events, the average value was 0.14. During wet periods it fell in the range of 0.05, while during dry periods it rose as high as 0.28.

Figure 10 shows that DO in the pond had little effect on DO in the runoff. This is understandable since the elevated levels in the pond ($DO > 10$ mg/l) reflected heavy respiration by algae during the day. The field was effective in removing the algae at the low loading rate used. It may also be seen from Figure 10 that downstream DO behaved somewhat independently of runoff DO. At the beginning and end of the period, upstream and downstream DO were close together. In between, downstream values were consistently lower than those upstream. This probably was caused by decomposition of tree litter in the swamp during the early warm season.

Data for BOD (Figure 11) and TKN (Figure 12) show that spray field runoff did not significantly degrade stream quality for these parameters. A seasonal rise in NO_3-N was apparent (Figure 13) in the stream, probably derived from the surrounding agricultural area which drained into the creek. Runoff nitrate was insignificant during this period. It would probably be higher during the cool season.

Table 6. Stream Flow Analysis

Date	Runoff	Cl, mg/l Upstream	Downstream	$\frac{Q_r}{Q_d} = \frac{C_d - C_u}{C_r - C_u}$
4-14-82	161	4	37	0.21
4-20	174	7	21	0.08
4-26	120	0	11	0.09
5-3	153	5	14	0.06
5-10	175	5	12	0.04
5-18	244	6	17	0.05
5-25	210	8	51	0.21
6-15	225	7	57	0.23
6-22	217	13	71	0.28
7-14	171	9	28	0.12
8-10	110	1	19	0.17
Avg	178	6	31	0.14

Runoff contribution to stream phosphorus was significant (Figure 14). This was to be expected since system removal of phosphorous was approximately 50 percent, as observed in other studies.

PLOT STUDIES

This part of the project included application of both secondary and primary wastewater. Plots 2 and 3 received secondary throughout the project. Plots 1 and 4 received secondary during the first three quarters of 1982 and primary during 4th quarter 1982 and all of 1983.

Basic data are compiled in Appendix B. Results for several parameters are summarized in this section to aid in interpretation. There was very little loss of water from the plots by evapotranspiration as evidenced by the Cl balance (Table 7). Runoff water contained virtually the same Cl concentration as applied water. There also appeared to be negligible losses through downward percolation, due to soil characteristics. Observation of the perimeter ditch around the spray field showed presence of a clay zone 1 or 2 meters below the surface. A water level recorder at the site showed the water generally within 1 meter of the surface.

Results for TSS are shown in Table 8. Average TSS was slightly high (20 mg/l) for an activated sludge plant. This was caused by a high algae population in the holding pond. Water entering the pond from the plant consistently showed low solids. Plots 1, 2 and 3 were only partially effective in removing algae from the secondary waste water. Plot 4 (St. Augustinegrass) was considerably more effective than the other grasses, due to greater vegetative density. Overland flow was much more effective in removing sewage solids. Average vaules for plots 1 and 4 during 1983 were 5.0 mg/l and 4.1 mg/l, respectively, while applied primary wastewater averaged 74 mg/l.

Runoff BOD was below 10 mg/l for plots receiving secondary wastewater(Table 9). Values for the primary wastewater was slightly higher than for secondary wastewater.

Runoff TKN did not exceed 2.5 mg/l for plots with secondary (Table 10). Values with primary were considerably higher. This reflected incomplete nitrification under the greater load of TKN.

Table 11 summarizes data for total P. Runoff concentration was independent of preapplication treatment.

Average reductions in TSS, BOD, TKN and total P are shown in Table 12. For analyses with secondary wastewater reductions were for runoff compared to raw sewage. Reductions were essentially the same for all plots: TSS = 93, BOD = 95, TKN = 92 and total P = 35 percent. For analyses with primary waste, reductions were from primary to runoff. Reductions for plots 1 and 4 averaged: TSS = 93, BOD = 89, TKN = 62 and Total P = 35 percent. Removal of BOD and TKN was less effective for primary than secondary. This again reflects greater solids loading. Plot 1 showed greater reductions than 4. Vegetation (St. Augustine) on plot 4 grew so vigorously, reaching a height of approximately 1 meter, that it may have limited oxygen transfer. During 1983 the vegetation on plot 1 was pennywort, having completely displaced bahiagrass.

SEASONAL EFFECTS

An objective of this study was to evaluate seasonal changes in treatment efficiency. Parameters chosen for this evaluation include TSS, BOD and TKN. Data for 1983 were used. Response to primary wastewater was determined by averaging data from plots 1 and 4; plots 2 and 3 were used to obtain response to secondary (pond) wastewater. Results are shown in Figure 15-20. No seasonal trends are apparent, i.e., treatment efficiency remains essentially constant throughout the year. It should

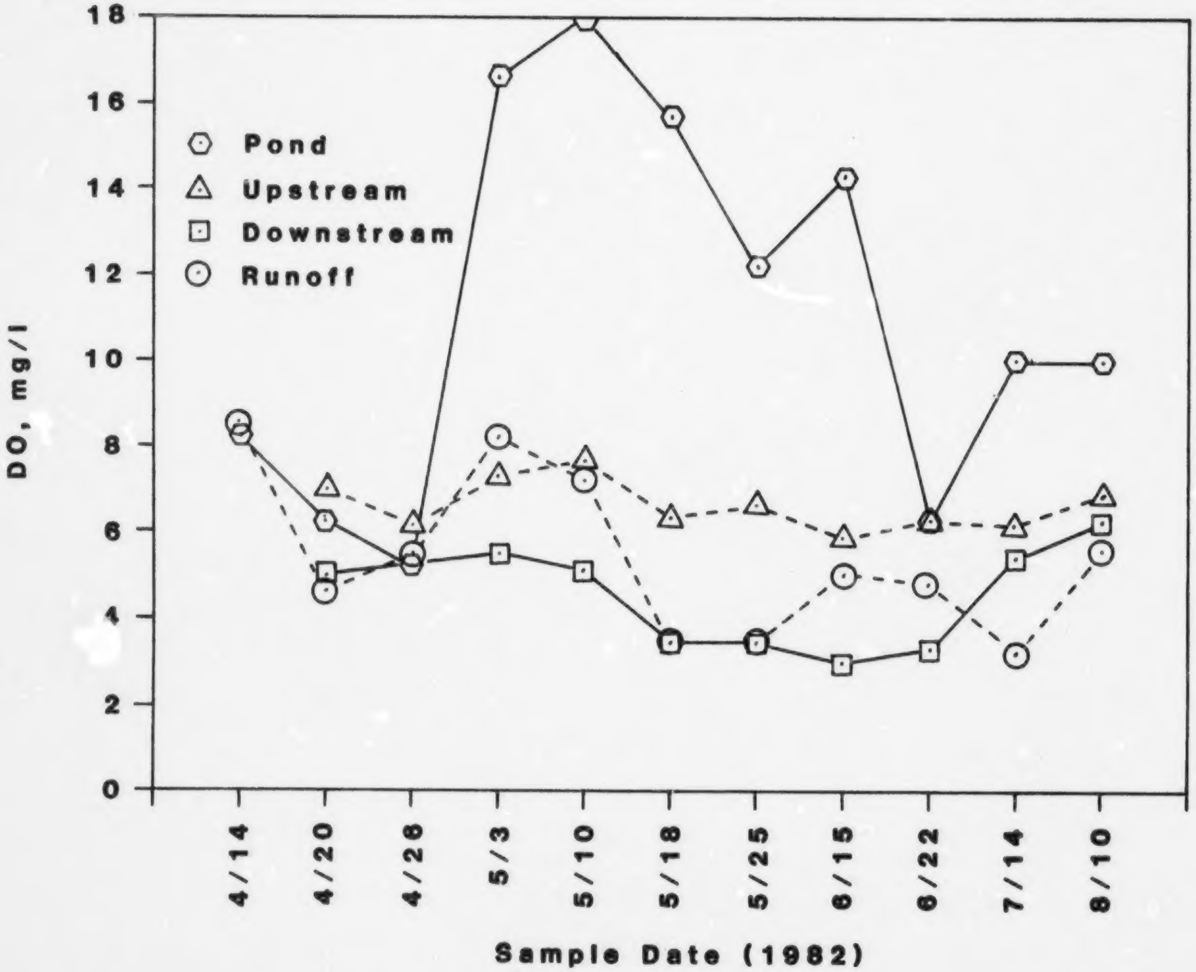

Figure 10. Dissolved Oxygen Results for Stream Study.

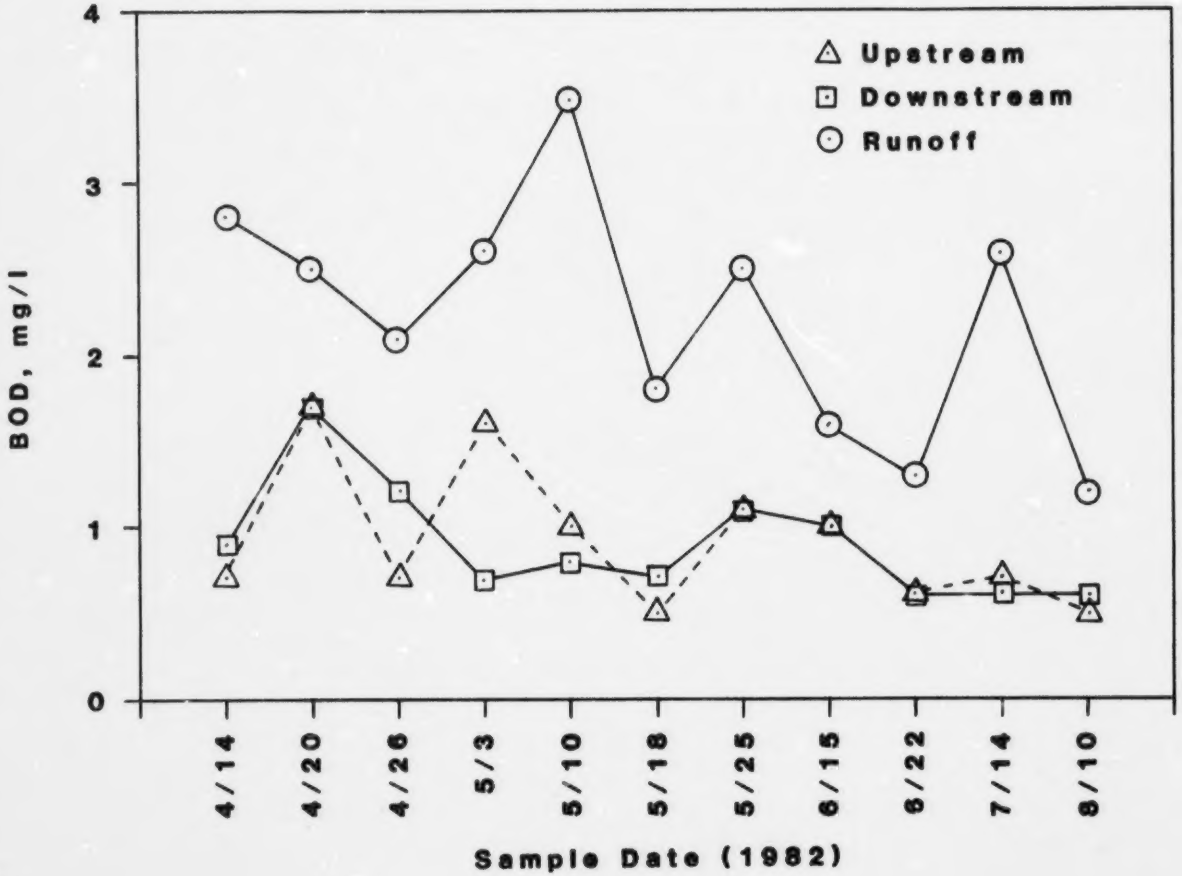

Figure 11. BOD Results for Stream Study.

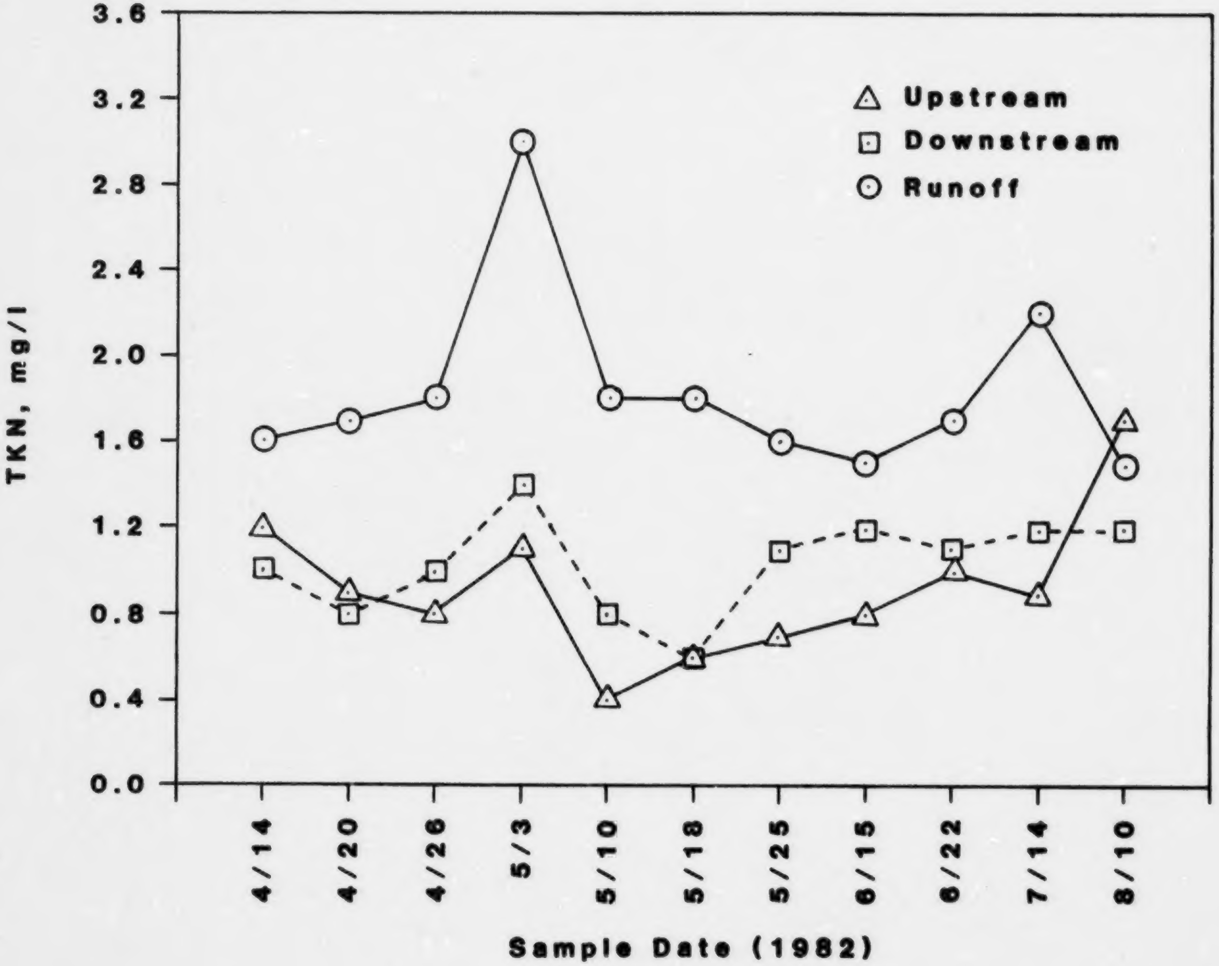

Figure 12. TKN Results for Stream Study.

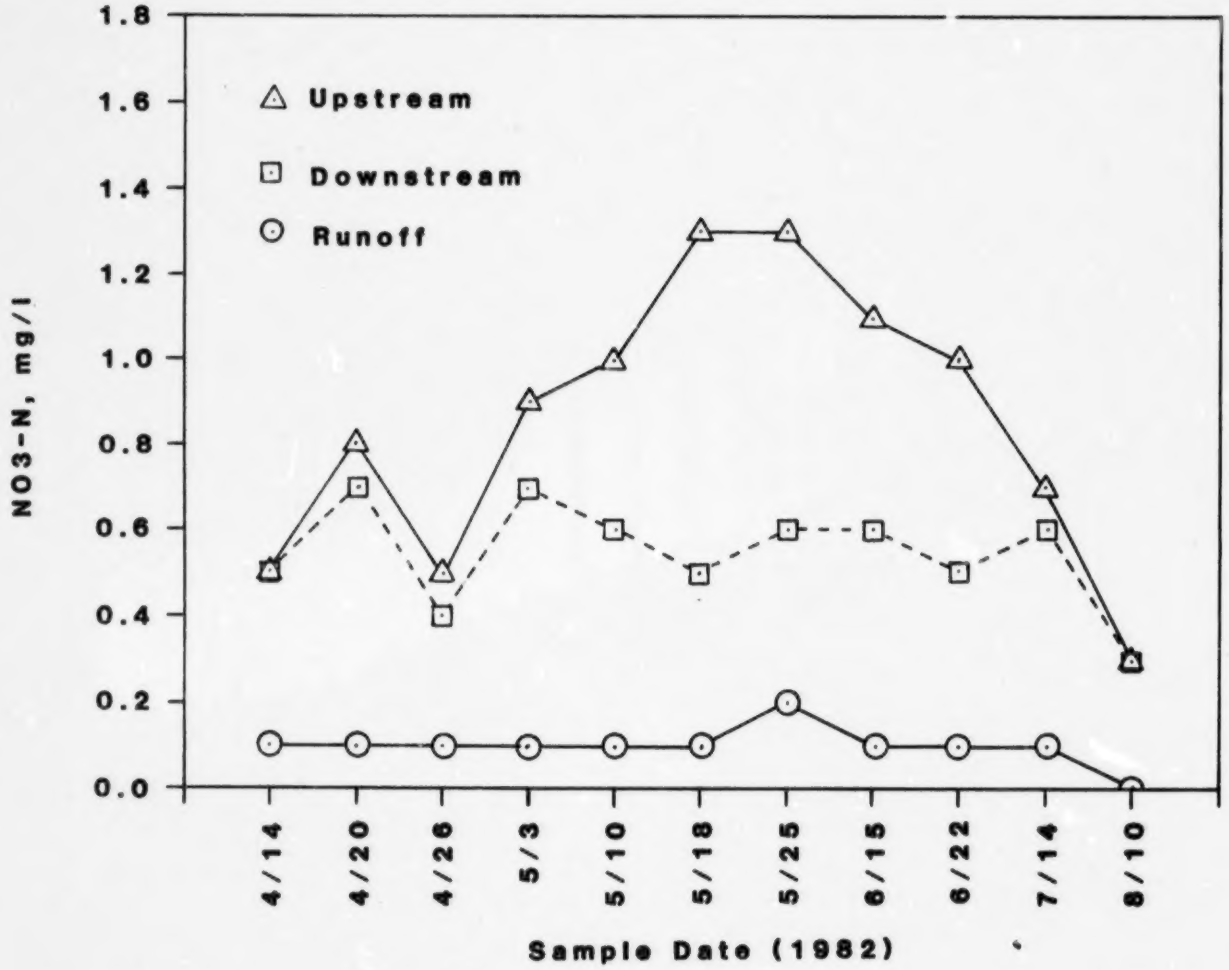

Figure 13. Nitrate Results for Stream Study.

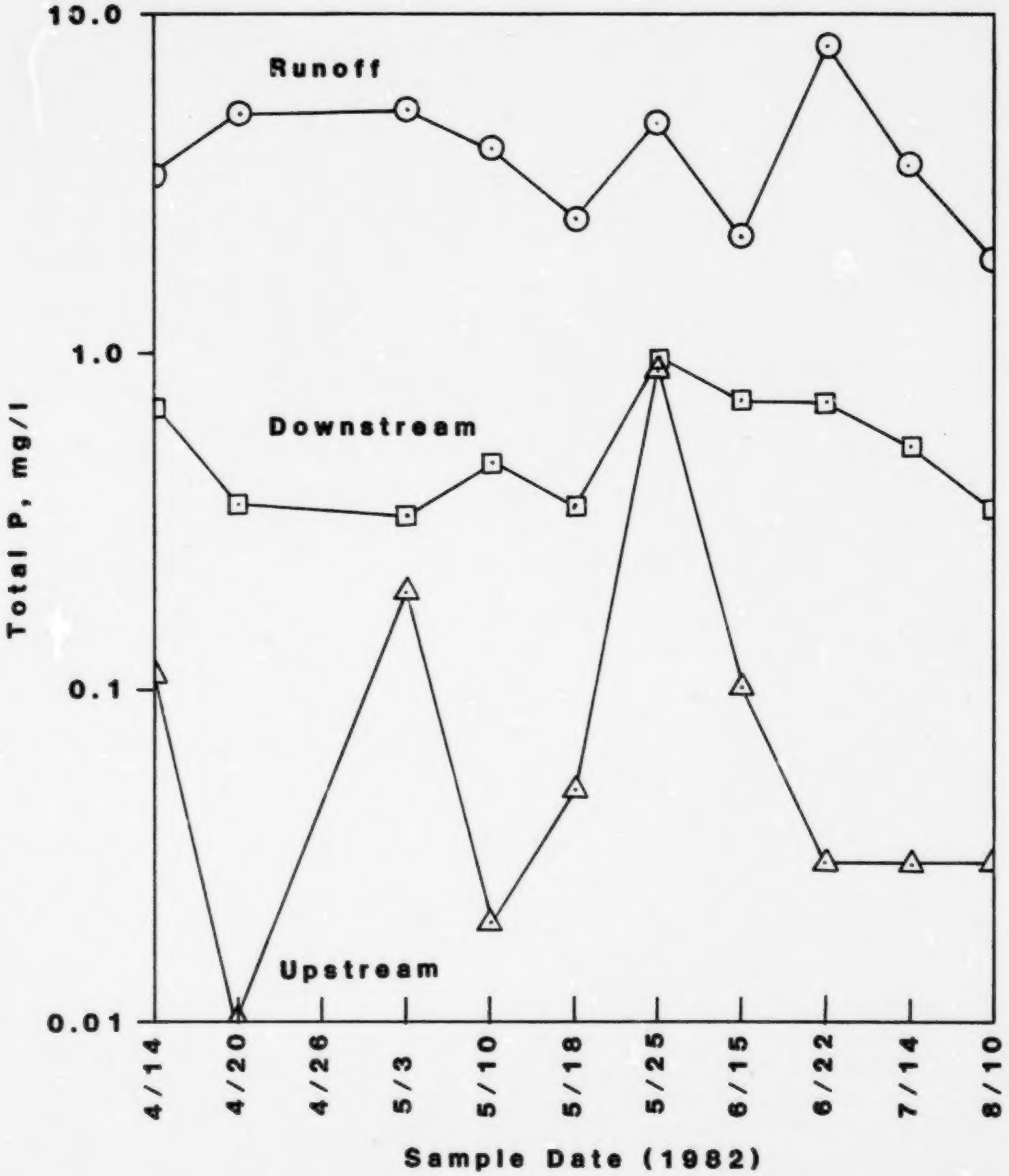

Figure 14. Total Phosphorus Results for Stream Study.

Table 7. Cl Summary for Plot Studies

Year	Quarter	Cl, mg/l						
		Raw	Pond	2	3	1	4	Primary
1982	1	-	174	146	143	142	137	-
	2	-	177	189	187	188	188	-
	3	-	157	160	172	168	160	-
	4	-	175	180	182	-	-	-
	avg	-	164	169	171	166	162	-
1983	1	119	115	113	110	100	103	118
	2	145	137	142	139	139	144	139
	3	169	164	166	165	178	157	161
	4	190	203	225	198	-	199	193
	avg	156	155	162	153	141	149	153

Table 8. TSS Summary for Plot Studies

Year	Quarter	TSS, mg/l						
		Raw	Pond	2	3	1	4	Primary
1982	1	125	20	14.	15.	12.	3.4	-
	2	121	36	12.	13.	11.	5.4	-
	3	138	24	9.6	8.6	7.4	6.0	-
	4	146	7.3	4.3	5.9	-	-	-
	avg	132	22	10.	11	10.	4.9	-
1983	1	88	10.	5.4	5.7	4.7	3.2	74
	2	105	34	12.0	13.8	6.6	5.5	70
	3	124	18.	7.8	7.6	3.7	3.3	83
	4	76	15.	4.0	6.2	-	4.5	70
	avg	98	19	7.3	8.3	5.0	4.1	74

Table 9. BOD Summary for Plot Studies

Year	Quarter				BOD, mg/l			
		Raw	Pond	2	3	1	4	Primary
1982	1	112	8.5	8.4	8.2	7.0	4.6	-
	2	137	13.0	10.	9.0	9.0	6.0	-
	4	122	19.3	6.4	6.1	6.2	3.6	-
	avg	123	8.7	7.2	6.6	7.4	4.7	-
1983	1	69	5.9	3.7	3.8	8.0	8.3	58
	2	20	20.0	8.1	6.8	8.8	11.4	71
	3	115	10.0	4.7	4.0	4.4	10.1	98
	4	80	6.3	3.5	3.3	-	11.6	74
	avg	87	11.0	5.0	4.5	7.1	10.4	75

Table 10. TKN Summary for Plot Studies

Year	Quarter				TKN, mg/l			
		Raw	Pond	2	3	1	4	Primary
	2	30.9	3.4	1.9	2.3	2.2	1.6	-
	3	31.9	6.3	2.4	3.0	2.7	1.9	-
	4	31.3	4.5	2.6	2.0	-	-	-
	avg	30.8	4.9	2.4	2.5	2.5	1.9	-
1983	1	22.2	2.4	1.8	2.0	8.9	11.4	22.6
	2	18.9	4.4	2.5	2.0	7.2	8.4	19.2
	3	23.4	4.0	2.0	1,7	4.6	7.8	22.7
	4	22.3	2.5	1.5	1.4	-	11.9	24.5
	avg	21.7	3.3	2.0	1.8	6.9	9.8	22.2

Table 11. Total P Summary for Plot Studies

Year	Quarter	Total P, mg/l						
		Raw	Pond	2	3	1	4	Primary
1982	1	-	7.7	5.5	6.0	5.7	5.7	-
	2	8.9	6.9	3.7	3.9	4.6	5.8	-
	3	7.4	6.2	4.9	4.8	4.7	5.0	-
	4	7.9	7.4	5.4	6.1	-	-	-
	avg	8.1	7.1	4.9	5.2	5.0	5.5	-
1983	1	5.9	4.1	3.3	3.5	2.5	3.4	4.1
	2	6.1	5.2	3.1	3.8	3.4	3.7	5.2
	3	7.5	5.7	4.2	4.5	3.6	4.6	5.7
	4	6.7	7.7	6.1	6.8	-	5.1	7.7
	avg	6.6	5.7	4.2	4.6	3.2	4.2	5.7

TABLE 12. Average Percent Reduction for Plots

Parameter	Secondary				Primary	
	1	2	3	4	1	4
TSS	92	93	91	96	93	94
BOD	94	94	95	96	91	86
TKN	92	92	92	94	69	56
TP	38	39	34	32	44	26

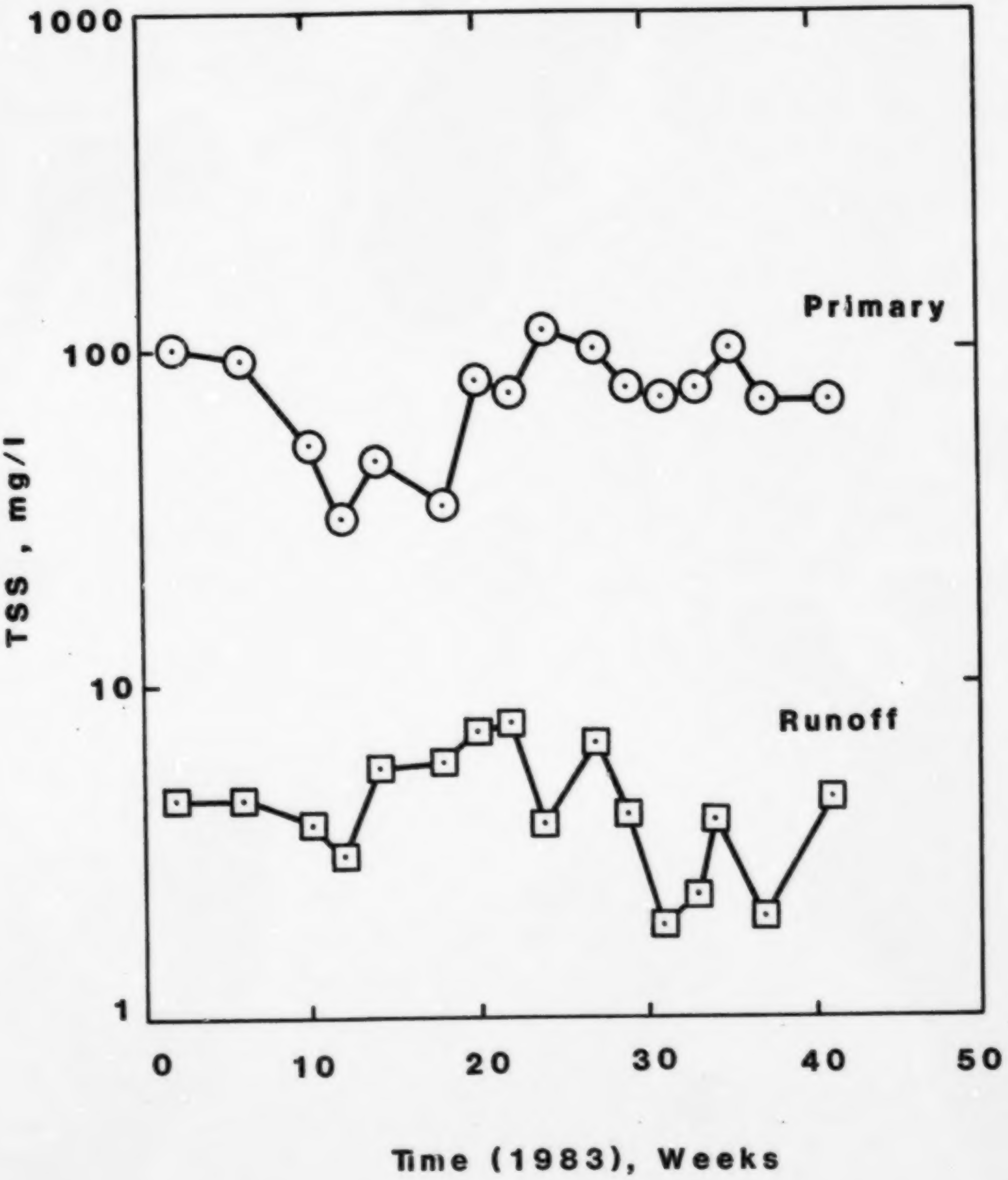

Figure 15. Seasonal Response of TSS for Primary and Runoff.

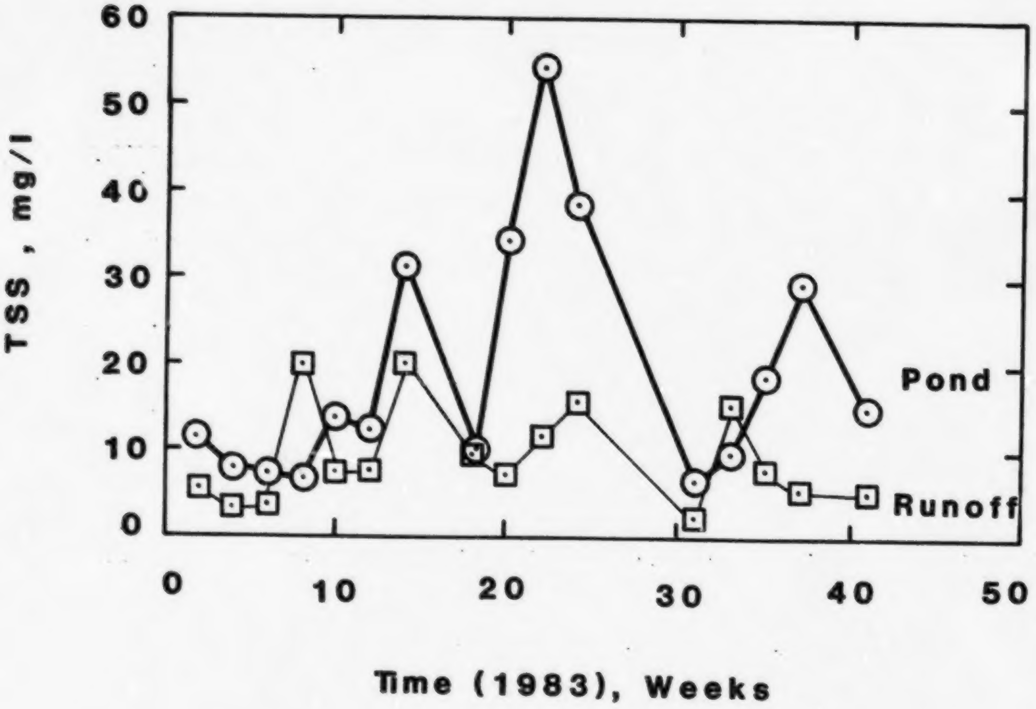

Figure 16. Seasonal Response of TSS for Pond and Runoff.

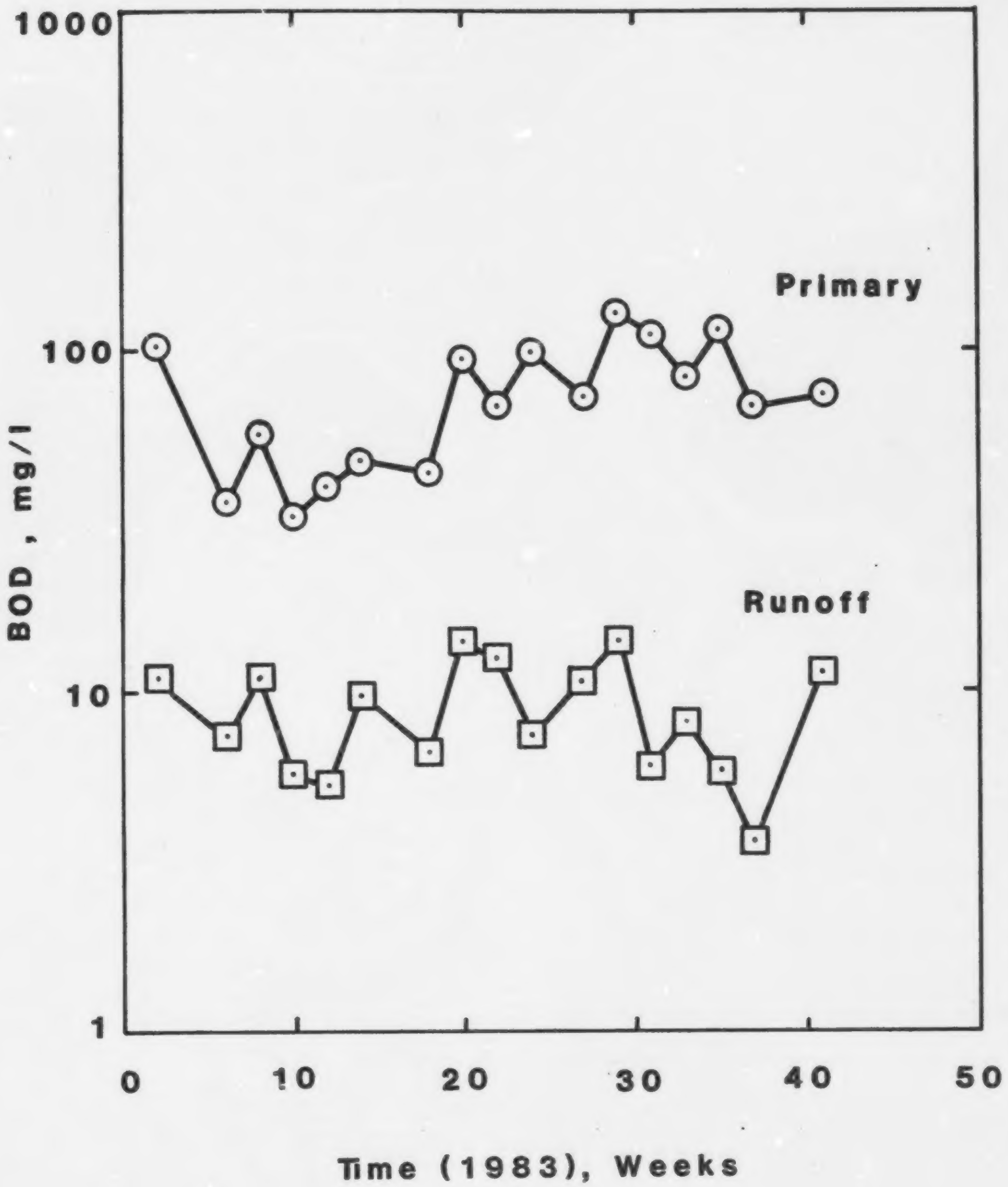

Figure 17. Seasonal Response of BOD for Primary and Runoff.

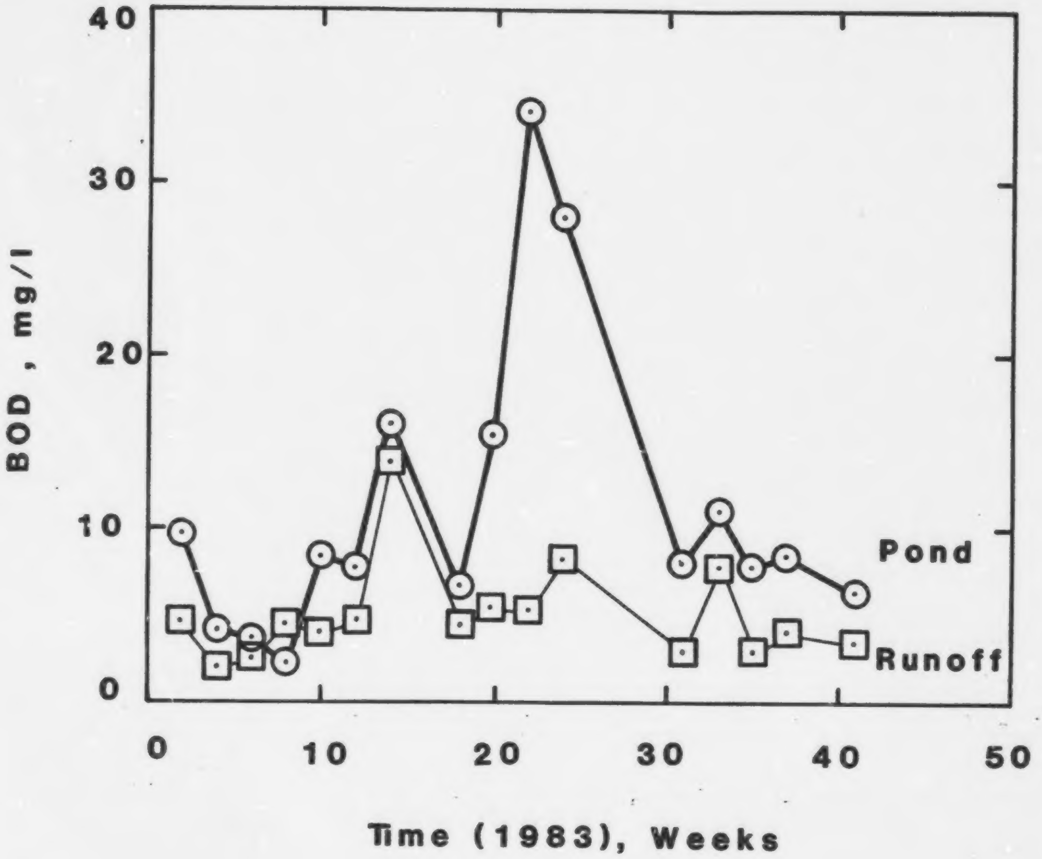

Figure 18. Seasonal Response of BOD for Pond and Runoff.

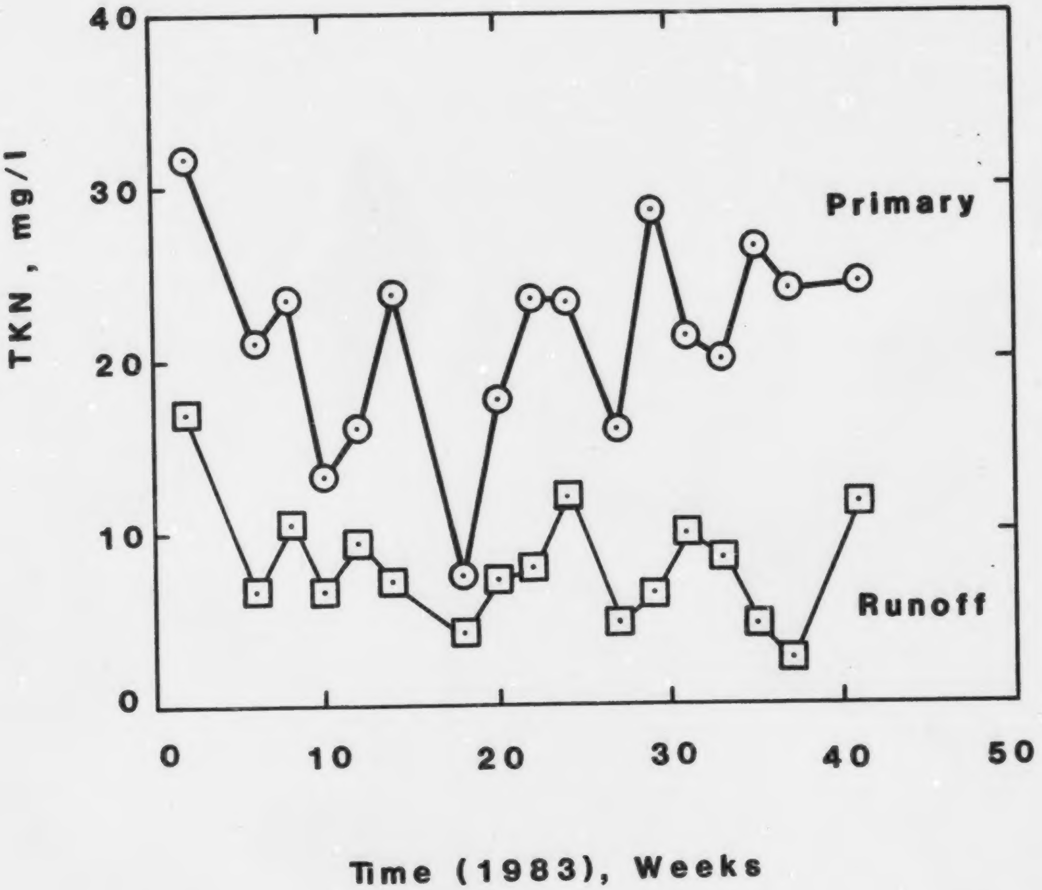

Figure 19. Seasonal Response of TKN for Primary and Runoff.

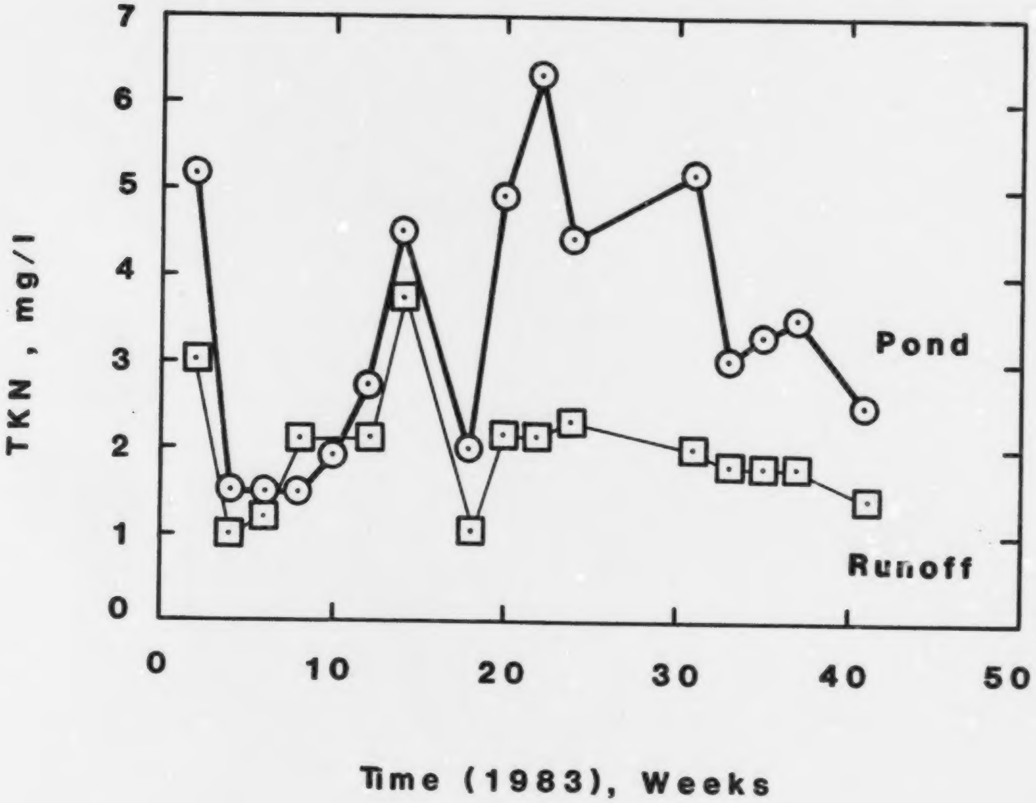

Figure 20. Seasonal Response of TKN for Pond and Runoff.

be pointed out that no significant ice formation occurred on the plots during these measurements. This could have disrupted flow patterns and thereby treatment efficiency. It may be of interest to note that same stability in the overland flow system at Florida State Prison.

RESIDENCE TIME MEASUREMENTS

Overland flow treatment is one of many processes which all depend on the amount of time spent on the process, i.e., the mean residence time. The determination of the mean residence time facilitates the calculation of hydraulic characteristics such as mean flow velocity and mean flow depth as well as mass transfer characteristics such as a dispersion coefficient, D and a mass transfer coefficient, k. To determine the mean residence time, assume (Levenspiel, 1972) that the plot is a controlled section and that plot influent and effluent conditions are plug flow (See Figure 21).

Using the data for the tracer plots of Figures 22-26, we can calculate the mean residence time as a weighted average, or:

$$\bar{t} = \frac{\Sigma t_i C_i}{\Sigma C_i} \tag{5}$$

where $\bar{t}$ = mean residence time, min

C_i = concentration of effluent tracer at time, t_i, mg/l

A graphical representation of mean residence time versus flow rate, Figure 27, may be described by the power function

$$\bar{t} = 2940\ Q^{-0.797} \tag{6}$$

where Q = flow rate, liters/min.

A similar relation is seen for trickling filters (Clark, Viessman and Hammer, 1977) in which the residence time is a power function of hydraulic loading rate.

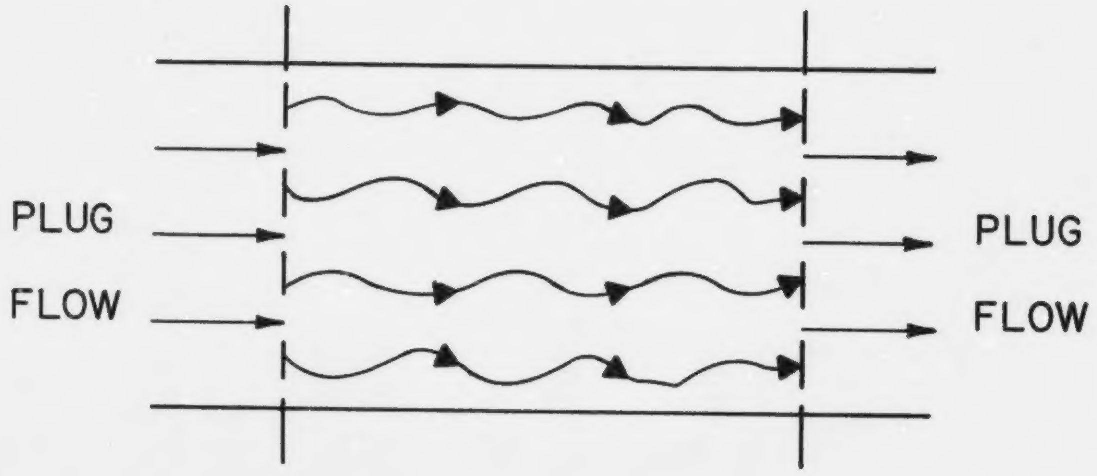

Figure 21. Controlled Section.

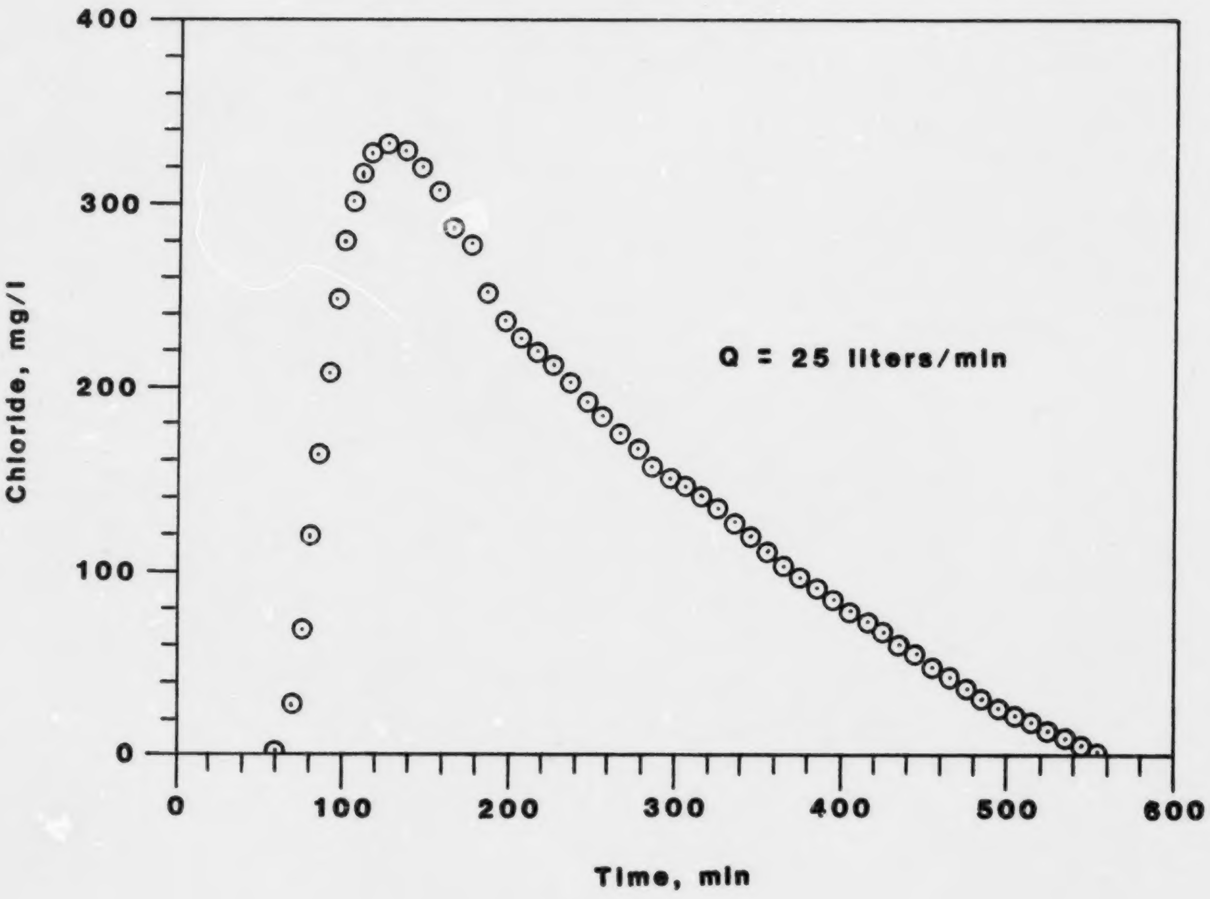

Figure 22. Salt Tracer Plot for Q=25 liters/min.

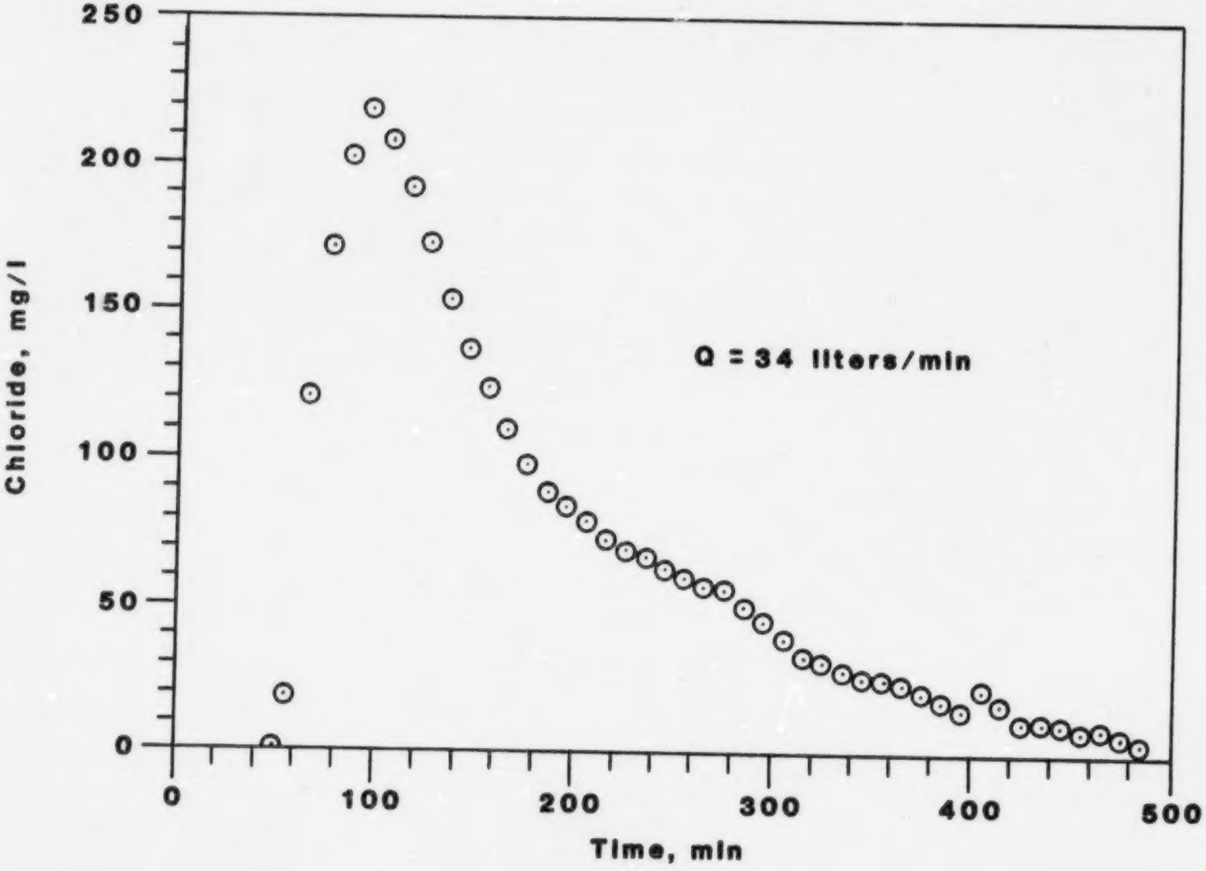

Figure 23. Salt Tracer Plot for Q=34 liters/min.

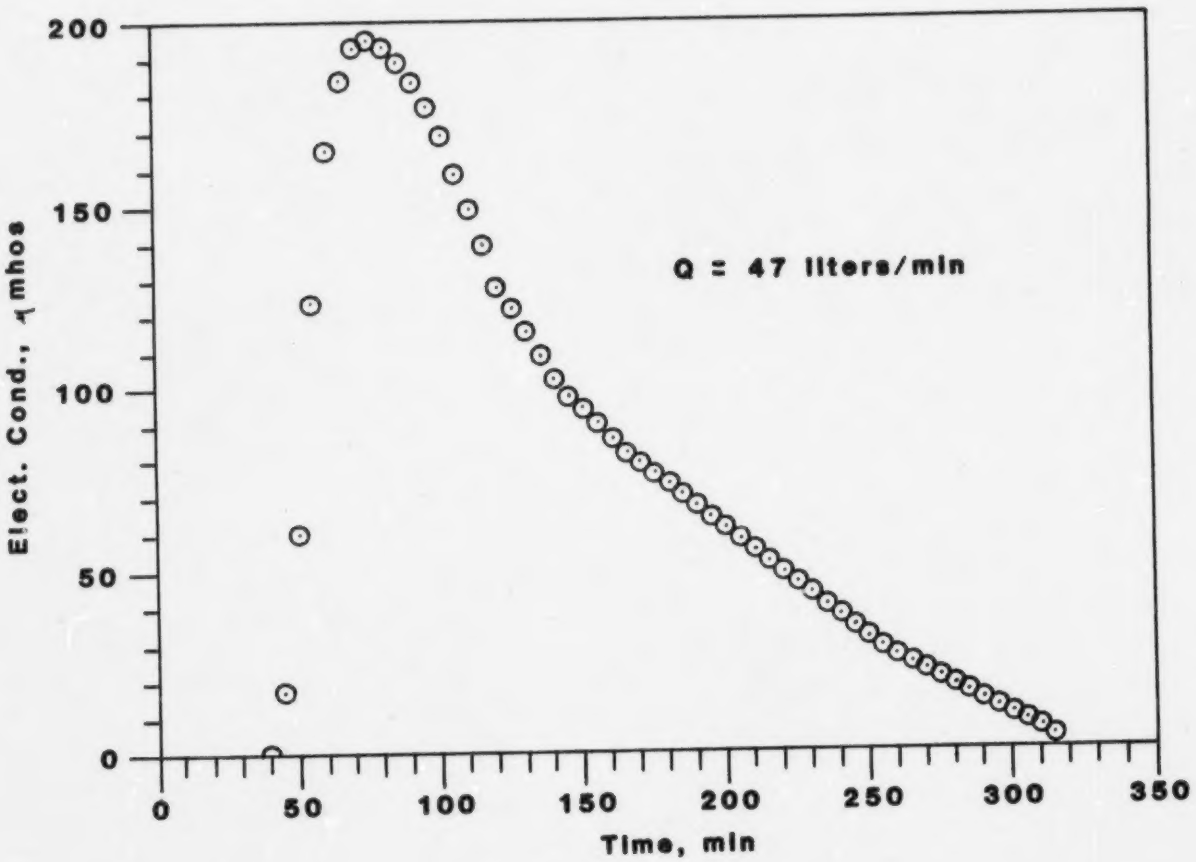

Figure 24. Salt Tracer Plot for Q=47 liters/min.

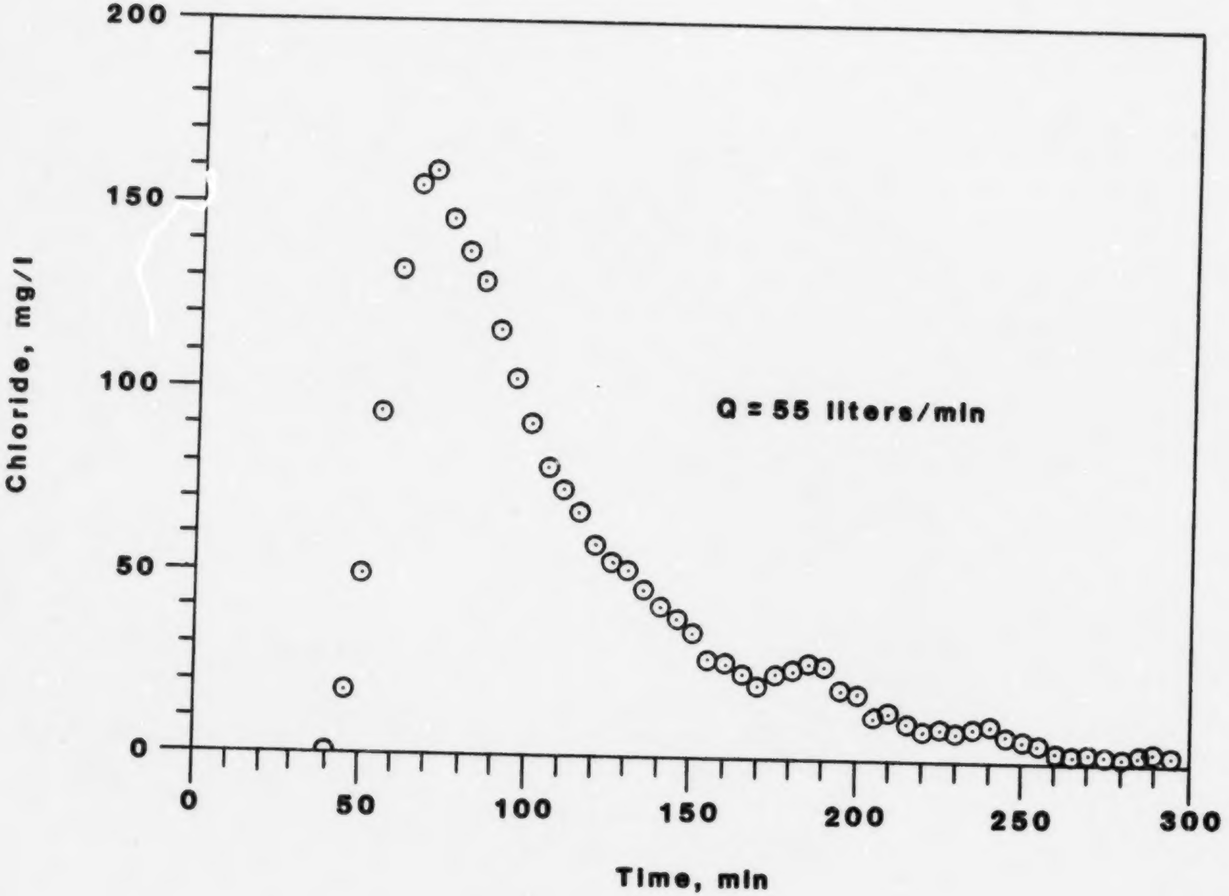

Figure 25. Salt Tracer Plot for Q=55 liters/min.

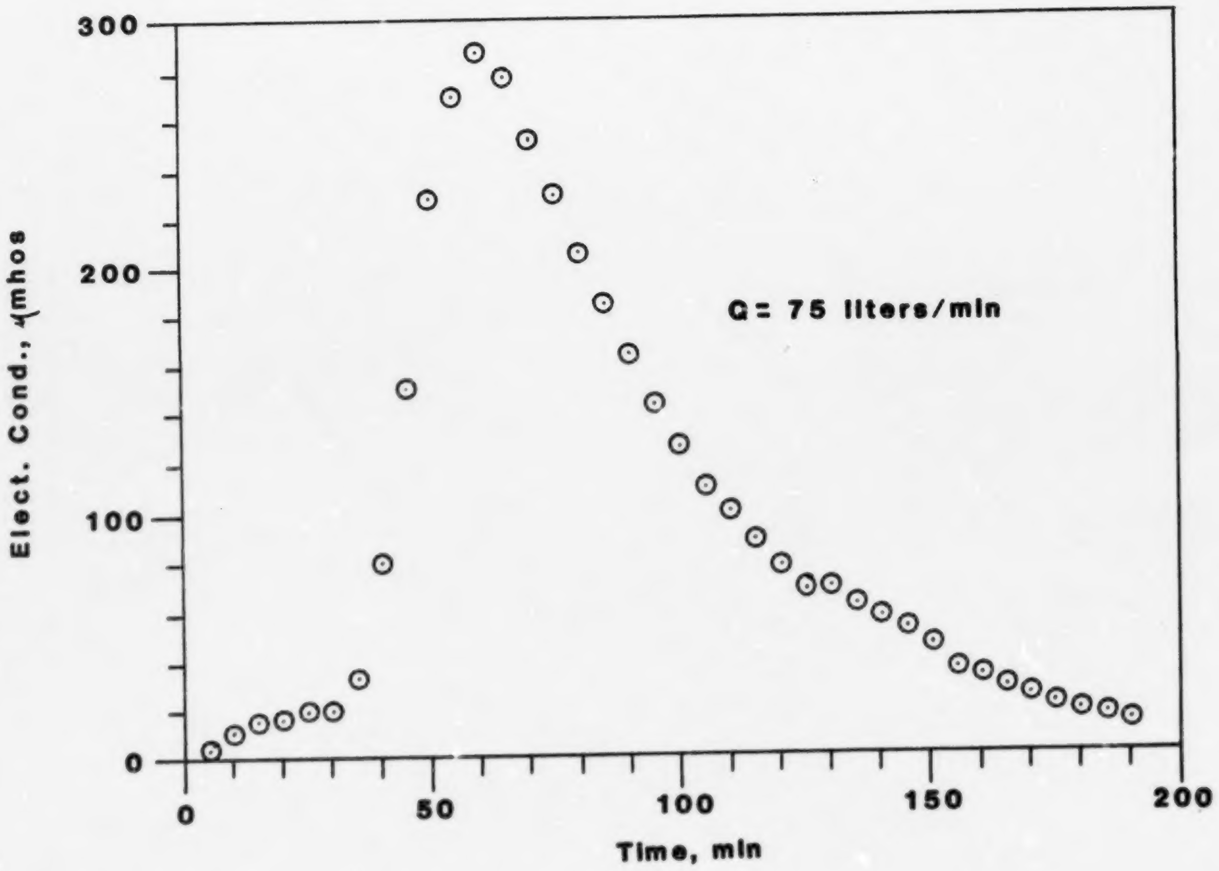

Figure 26. Salt Tracer Plot for Q=75 liters/min.

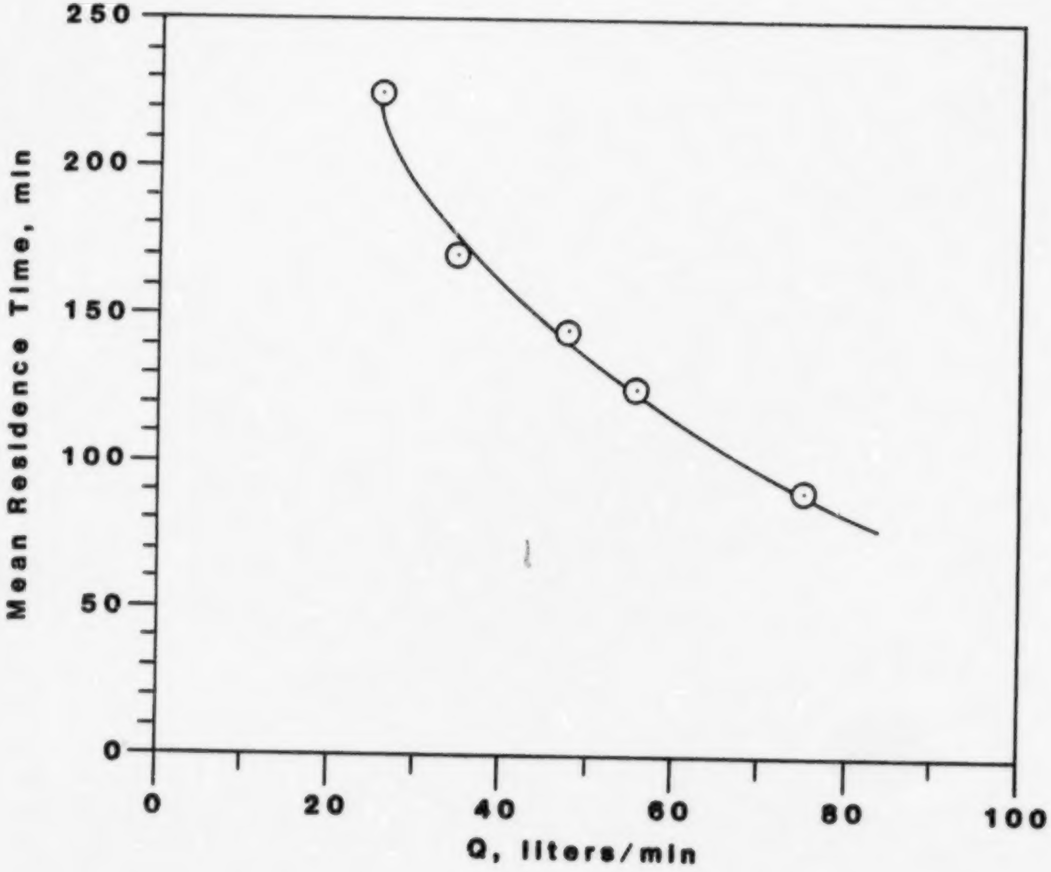

Figure 27. Mean Residence Time versus Pumping Rate.

From the mean residence time, the mean flow velocity can be calculated by dividing the field length, 30.5 meters, by $\overline{t}$. From Figure 28, the relation of mean velocity to flow rate is:

$$U = 0.0117\ Q^{0.767} \tag{7}$$

where U = mean velocity, m/min.

All velocities for plot 4 were under 0.5 meter/min.

The mean depth of flow is a function of both velocity and flow rate and was calculated from:

$$d = \frac{Q}{U \cdot W}\ 10^{-3} = 0.700\ Q^{0.233} \tag{8}$$

where d = mean flow depth, m
W = plot width (= 12.2 m for plot 4).

All flow depths for plot 4 were between 1.0 and 2.0 cm. A graphical representation of depth versus velocity is shown in Figure 29.

Method of Residence Time Tests

With the use of a Tuthill positive displacement pump and a variable speed motor, the flow rates were varied between 25 and 75 liters/min at 5 different settings. Once the pumping rate was set, steady state conditions on the plot were insured using an ISCO 1870 flow meter in the trapezoidal collection flume. When the depth remained constant steady state conditions had been reached. With the system at steady flow, a plug solution of table salt was injected into the distribution manifold supply pipe (Figure 30).

Once the salt solution was in the manifold, sampling was done in the trapezoidal flume for either chloride or electrical conductivity at equal time increments. The influent was also sampled for changing influent conditions at longer time increments. The earlier tests were done by electrical conductivity for ease of testing and immediate results. Chloride tests were used later to provide better tracer data.

The curves of Figures 22-26 were obtained by plotting the effluent data, plotting the influent data, shifting the influent data curve by an estimated time, $\overline{t}$ and subtracting this influent curve from the effluent curve. If the calculated $\overline{t}$ didn't match the estimated $\overline{t}$ then a new $\overline{t}$ was chosen and the influent curve was shifted again. This process was done until the $\overline{t}$ calculated matched the $\overline{t}$ estimated.

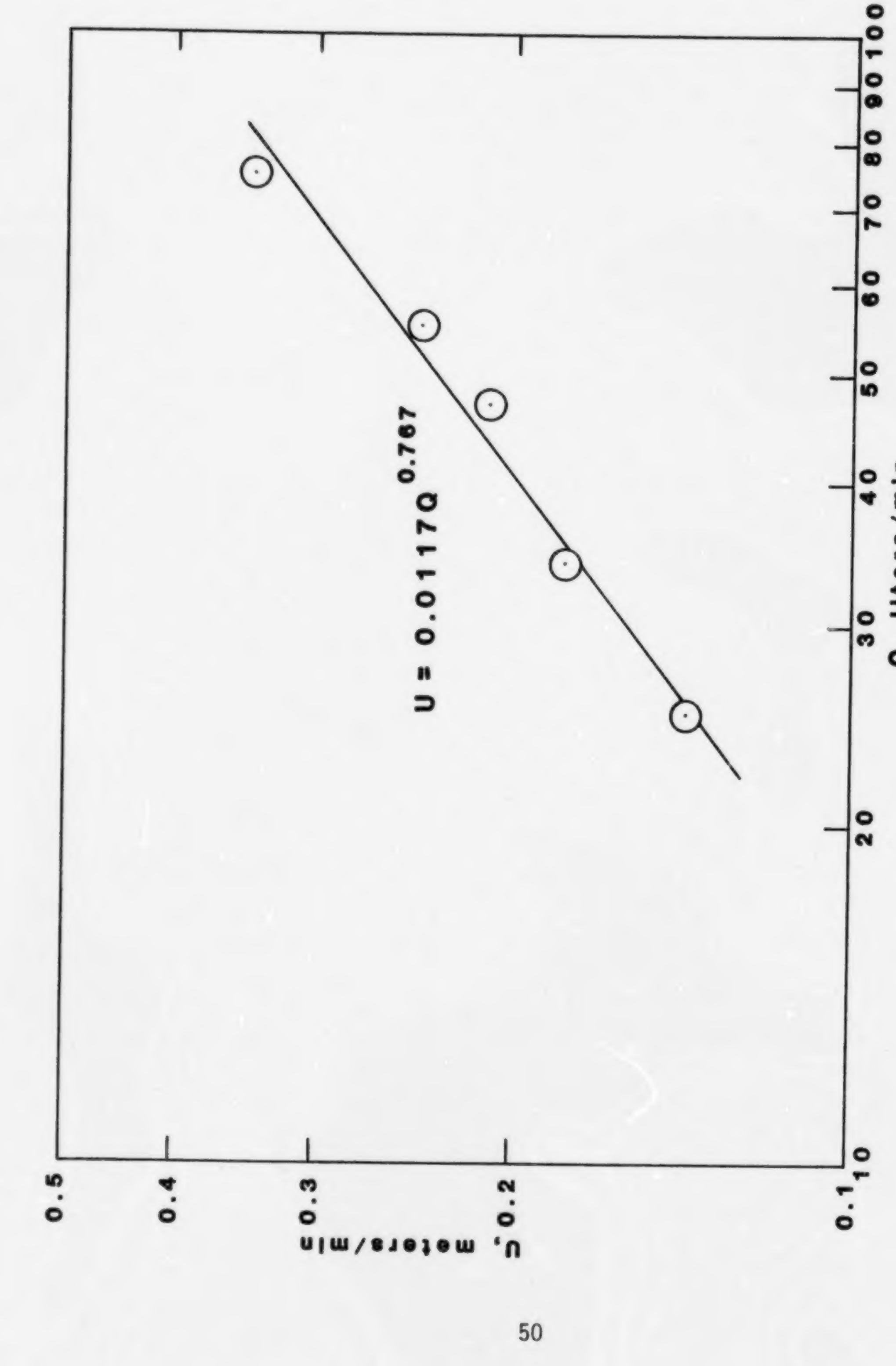

Figure 28. Mean Velocity versus Pumping Rate.

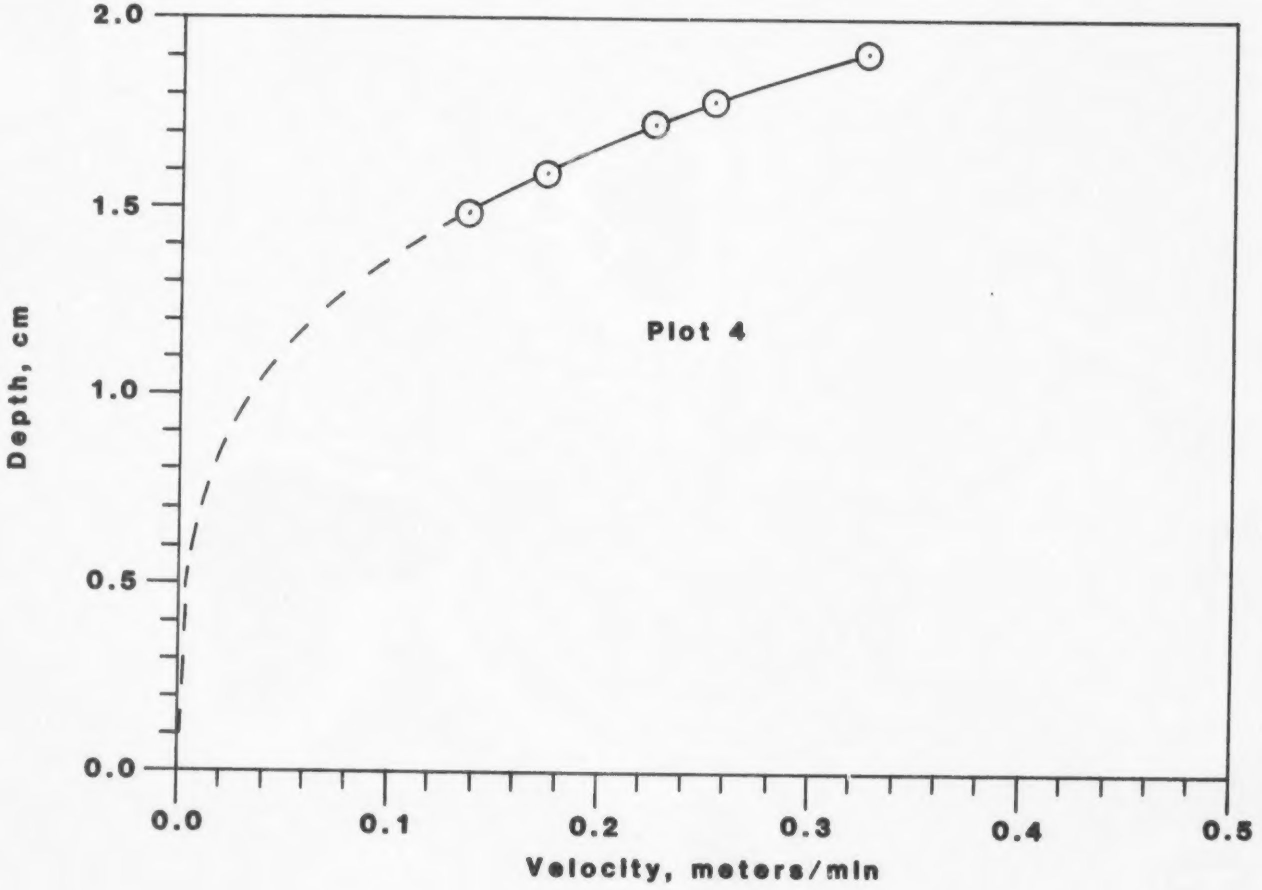

Figure 29. Mean Depth versus Mean Velocity.

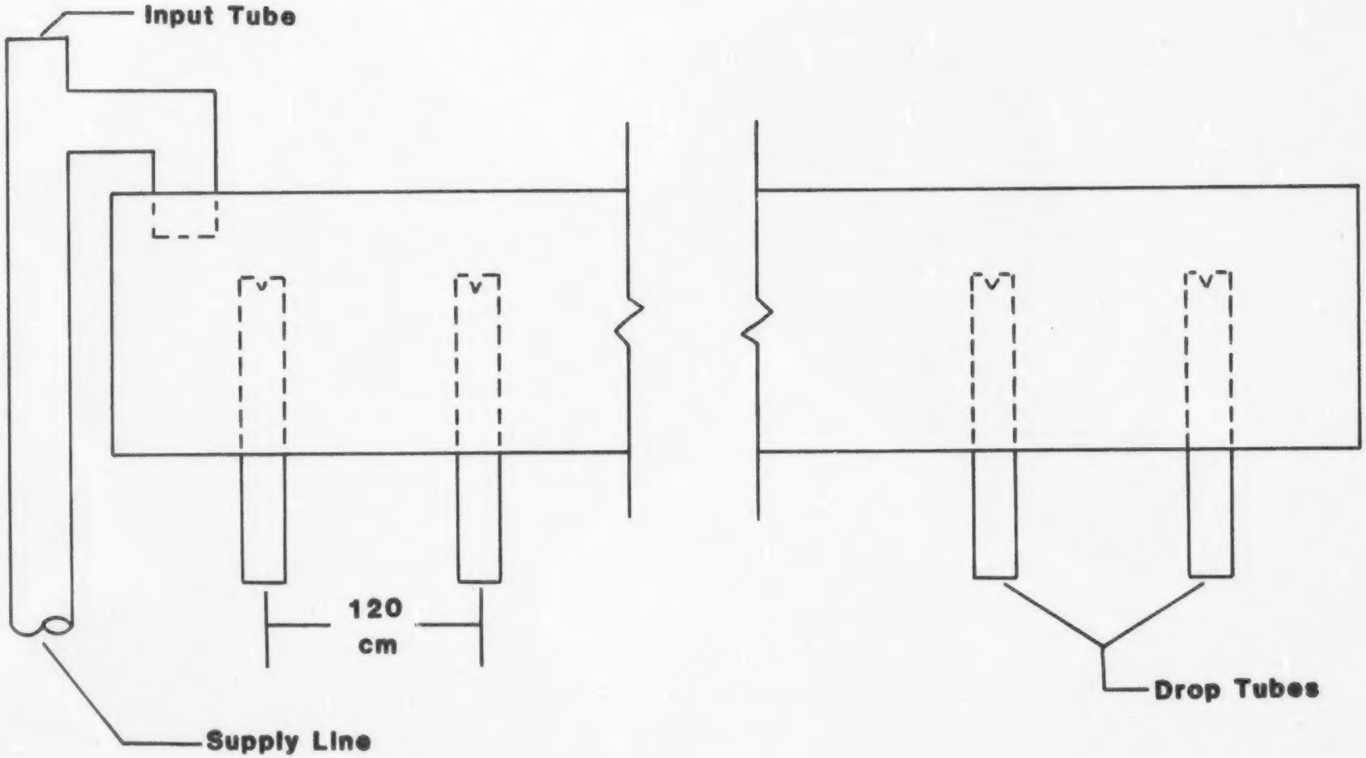

Figure 30. Distribution Manifold.

The residence time test was performed for flow rates of 25, 34, 47, 55 and 75 liters/min. The conversion of application rates are listed in Table 13.

Table 13. Application Rate Conversion

PUMPING RATE		LOADING RATE	
$\frac{\text{liters}}{\text{min}}$	$\frac{\text{gallons}}{\text{min}}$	$\frac{\text{cm}}{\text{week}}$	$\frac{\text{in}}{\text{week}}$
25	6.5	14.0	5.5
34	9.0	19.3	7.6
47	12.4	26.4	10.4
55	14.5	31.3	12.3
75	19.8	42.2	16.6

TRANSPORT PROCESSES

The most important processes of overland flow treatment are that of mixing (or dispersion) and mass transfer. Dispersion is that mechanism which determines the uniformity of the fluid with respect to concentration.

Upon comparison of the concentration curves for the various application rates of Figures 22-26 with the C - curves of Levenspiel (1972), one can conclude the dispersion model for the C - curves will simulate the concentration curves.

The dispersion model is

$$\frac{\sigma^2}{\bar{t}^2} = 2 \frac{D}{UL} - 2 \left(\frac{D}{UL} \right)^2 \left(1 - e^{-UL/D}\right) \qquad (9)$$

where $\frac{D}{UL}$ = dispersion number, dimensionless
U = mean velocity, m/min
L = flow length, m
σ^2 = variance of tracer curve, min^2
$\bar{t}$ = mean residence time, min

The variance is given by

$$\sigma^2 = \frac{\Sigma\, t_i^2\, C_i}{\Sigma\, C_i} - \bar{t}^{\,2} \qquad (10)$$

Note that for $\frac{D}{U L} \ll 1$, Equation (9) reduces to

$$\frac{\sigma^2}{\bar{t}^2} = 2 \frac{D}{U L} - 2 \left(\frac{D}{U L}\right)^2 \qquad (11)$$

and can be solved for $\frac{D}{U L}$.

For each of the five different flow rates of Figures 22-26 a dispersion coefficient was determined and plotted against velocity in Figure 31a. The relation of Figure 31a is of the form

$$D = 1.58\ U^{0.527}. \qquad (12)$$

Substituting for U,

$$D = 0.151\ Q^{0.404} \qquad (13)$$

This relation follows transfer theory that dispersion increases with velocity.

By comparison of Figure 31 a and b it is concluded that dispersion is not adversely affected by increasing depth, due to the fact that the dispersion is increasing at a greater rate than the depth with increasing velocity. One must keep in mind that the dispersion is not strictly a function of velocity, but also depends on tortuous flow through the grass mat. However one is not able to include such a parameter in the analysis. Furthermore, as field conditions change, grass thins out in winter or becomes more lush in spring, the residence time will change and directly affect the flow velocity and rates of dispersion.

Table 14. Hydraulic Characteristics Of Plot 4.

Q l/min	q m^3/hr/m	$\bar{t}$ min	$\bar{t}_c^*$ min	U m/min	D m^2/min	d cm
25	0.12	225	226	0.135	0.52	1.48
34	0.17	170	177	0.172	0.64	1.59
47	0.23	144	137	0.223	0.76	1.72
55	0.27	125	121	0.252	0.79	1.78
75	0.37	90	94	0.325	0.80	1.91

*$\bar{t}_c$ is determined from regression of $\bar{t}$ vs Q.

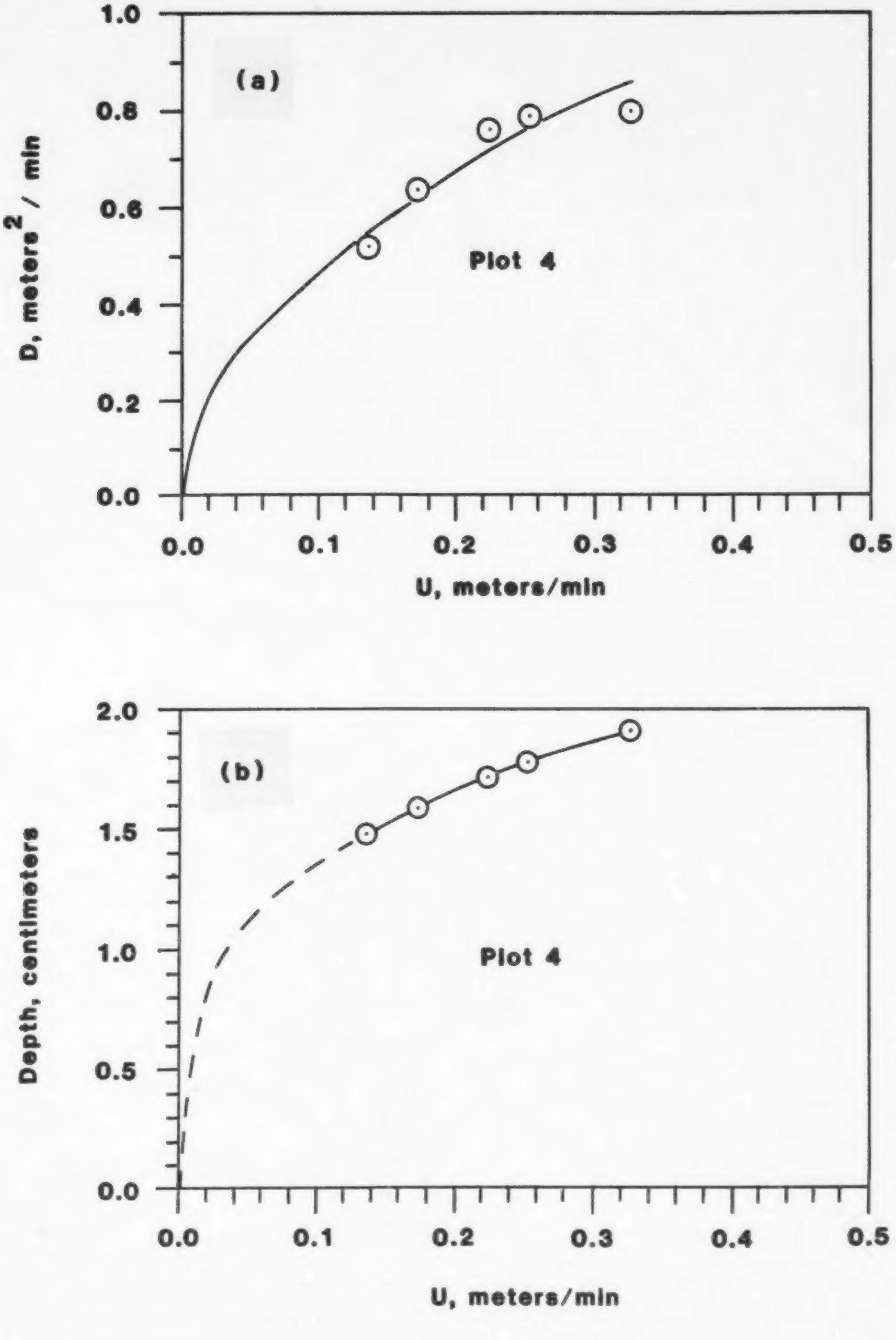

Figure 31. Dependence of D and d on Velocity.

A residence time test performed in March 1983 produced results which differed over 30 percent from those obtained in a similar test run in June, 1983. See Table 14 for summary of dispersion results.

Mass transfer is that mechanism which dicates the efficiency or performance of the treatment process in that it controls the food supply (nutrients in wastewater) of the biological organisms attached to the grass media. Research has shown that if the food can be transported to the media, the organisms will dispose of it.

The mass transfer equation for one dimensional steady state flow with a 1st order reduction process is given by (Overman et al., 1976)

$$D \frac{d^2C}{dx^2} - U \frac{dC}{dx} - kC = 0 \qquad (14)$$

With $C = C_0$ at $x = 0$, the solution becomes

$$\frac{C}{C_0} = e^{-(\sqrt{1 + \gamma} - 1)\, U\, x/2D} \qquad (15)$$

For $\gamma = \frac{4kD}{U^2} << 1$, Equation (15) reduces to

$$\frac{C}{C_0} = e^{-(k/U)\, x} \qquad (16)$$

For the Gretna data, γ is a significant value in Equation (15), as may be shown with values from Tables 14 and 16.

If $\alpha = -\ln \frac{C}{C_0}$, then Equation (15) reduces to

$$k = \frac{U\alpha}{x} \left(1 + \frac{D\alpha}{Ux}\right) \qquad (17)$$

Work performed by Abernathy (1983) and Smith (1982) indicate that treatment efficiency is in fact exponentially dependent on x in the form

$$\frac{C}{C_0} = e^{-\beta x} \qquad (18)$$

where from Equation (15)

$$\beta = (\sqrt{1 + \gamma} - 1)\, U/2D .$$

During the period beginning May 17, 1983 and ending September 13, 1983, samples were taken of the primary supply (C_0 at $x = 0$) and the plot runoff (C at $x = 30.5$ m) and analyses for mass transfer was performed for turbidity, total suspended solids, BOD and organic nitrogen. The operating conditions and C/C_0 ratios are listed in Table 15.

Table 15. Efficiency Data For Plot 4.

Date	Q 1/min	$\bar{t}$ min	U m/min	C/Co TURB	C/Co TSS	C/Co BOD	C/Co ORG N
5-17-83	47	144	0.21	0.112	0.074	0.173	0.390
5-31	34	170	0.18	0.126	0.124	0.215	0.397
6-16	55	125	0.24	0.041	0.038	0.103	0.004
7-5	34	170	0.18	-	0.063	0.162	0.238
7-19	34	170	0.18	0.100	0.056	0.111	-
8-2	47	144	0.21	0.107	0.026	0.073	-
8-16	47	144	0.21	0.139	0.035	0.148	0.318
8-29	25	225	0.14	0.061	0.030	0.075	0.510
9-13	24	225	0.14	0.071	0.020	0.081	0.308

Applying Equation 15, the mass transfer coefficients for these parameters were calculated and plotted against velocity in Figures 32-35. Data from the overland flow system at Florida State Prison (FSP) in Raiford, Florida was also used to determine mass transfer coefficients for comparison with those of Gretna. The length of flow as well as slope, grass type and loading differed significantly and yet the results from FSP follow those of the Gretna project. The mass transfer data and results are summarized in Table 16.

A comparison with data from Metcalf & Eddy (1979) for trickling filters indicates that for low velocities the relation between the mass transfer coefficient and velocity is linear.

Turbidity, suspended solids and BOD are very closely related by the fact that nearly 50 percent of the BOD is in the form of suspended solids and turbidity is a measure of the cloudiness due to suspended matter in the water. Therefore, these three parameters are directly proportional to each other. This relation can be seen in Figures 32-34 in the fact that the slopes and k values are in the same range.

Organic nitrogen, a measure of the amount of nitrogen due to organic material, exhibits a similar relationship between mass transfer and velocity, but to a lesser degree. A comparison of the FSP data yields the same conclusion in Figure 14 as was seen in Figures 32-34, that the relation between k and U has a smaller slope. The scatter of the organic nitrogen data is due to the fact that it is derived not analytically but from the subtraction of ammonia nitrogen from total kjeldahl nitrogen, both of which are produced from analytical methods. The results of Figure 29 indicate that the mass transfer of organic nitrogen is not as important as that of oxygen because oxygen appears to be the limiting factor for nitrification/denitrification processes. In addition, organic nitrogen content can in fact be increased on the plot due to decaying biological material such as bacteria and grass mat which would not give a true indication of treatment and would result in a depressed k versus U curve.

The net result of these correlations is that treatment efficiency, as given by Equation (18), is less sensitive to loading rate (through β) than to slope length.

The effect of pumping rate on treatment efficiency is shown in Figures 36-38. It appears from Figure 36 that TSS and BOD reduction was insensitive to pumping rate. This result may be explained by a linear coupling between mass transfer and convective transport, as concluded from Figures 33 and 34. In contrast, total N reduction was dependent upon pumping rate (Figure 37), exhibiting a linear decrease over the range measured. It is not clear from this graph which step in the N sequence Org N $\rightarrow$ NH_4 $\rightarrow$ N gas may be limiting overall reduction. Insight into this issue may be obtained from Figure 38. The ordinate gives NH_4-N in runoff divided by the sume of NH_4-N in the primary plus the change in Org N from primary to runoff. A ratio of one would indicate no nitrification (NH_4 $\rightarrow$ NO_3); conversely, zero would indicate

Table 16. Mass Transfer Data For Plot 4.

				k, 1/min			
Date	Q l/min	$\bar{t}$ min	U m/min	TURB	TSS	BOD	ORG N
5-17-83	47	144	0.21	0.019	0.024	0.015	0.0072
5-31	34	170	0.18	0.015	0.015	0.011	0.0060
6-16	55	125	0.24	0.034	0.035	0.022	0.0690
7-5	34	170	0.18	-	0.022	0.013	0.0099
7-19	34	170	0.18	0.017	0.023	0.016	-
8-2	47	144	0.21	0.020	0.036	0.024	-
8-16	47	144	0.21	0.017	0.032	0.016	0.0090
8-29	25	225	0.14	0.017	0.023	0.016	0.0033
9-13	25	225	0.14	0.016	0.027	0.015	0.0062

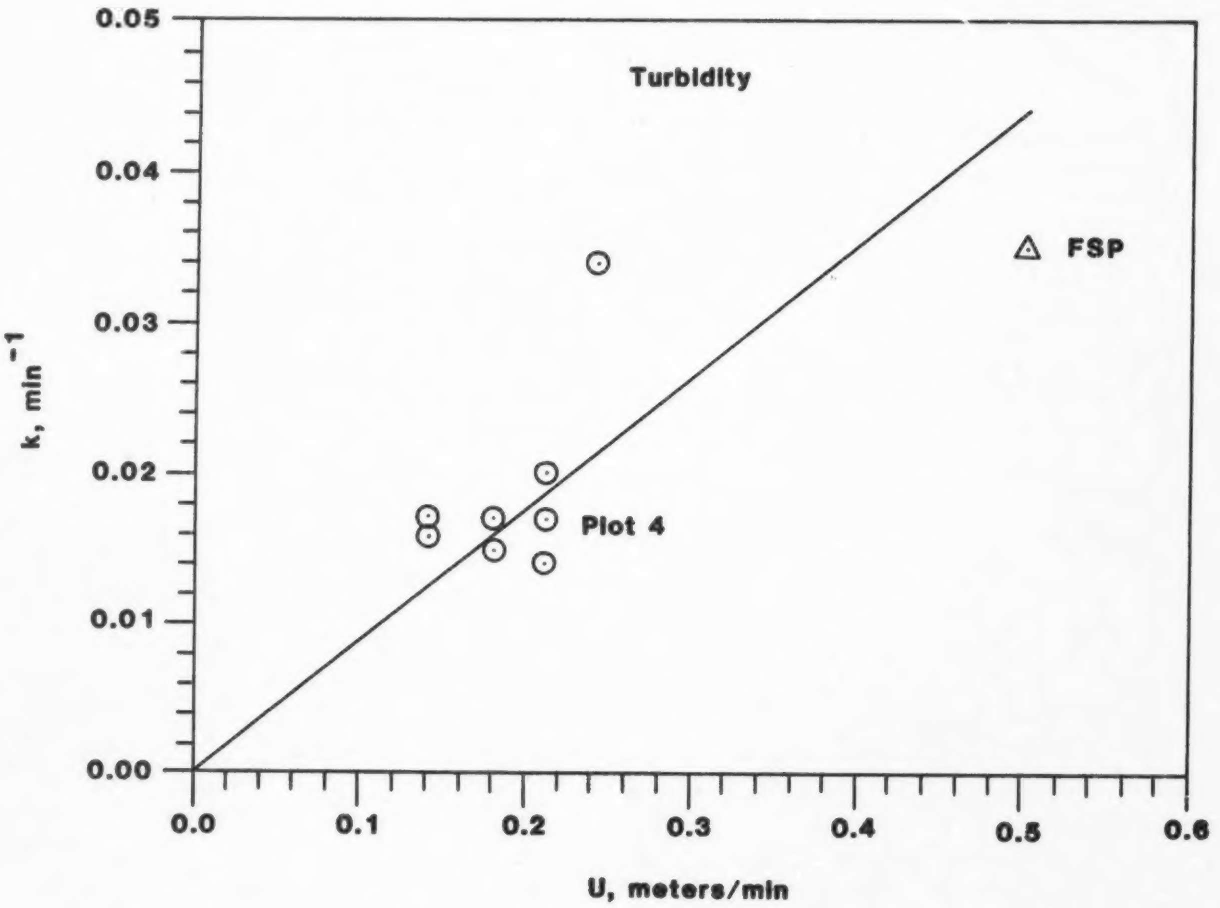

Figure 32. Dependence of Mass Transfer Coefficient on Velocity for Turbidity of Plot 4.

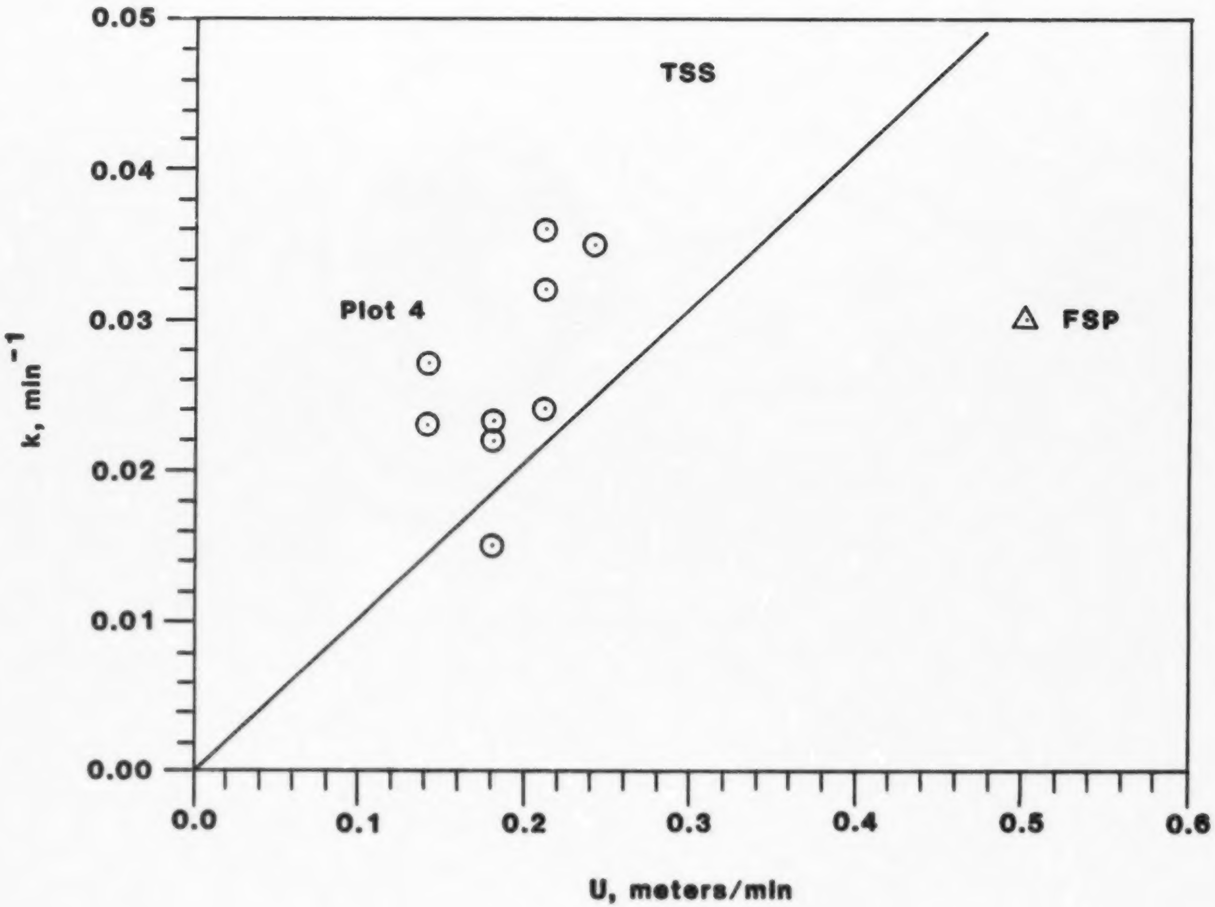

Figure 33. Dependence of Mass Transfer Coefficient on Velocity for TSS of Plot 4.

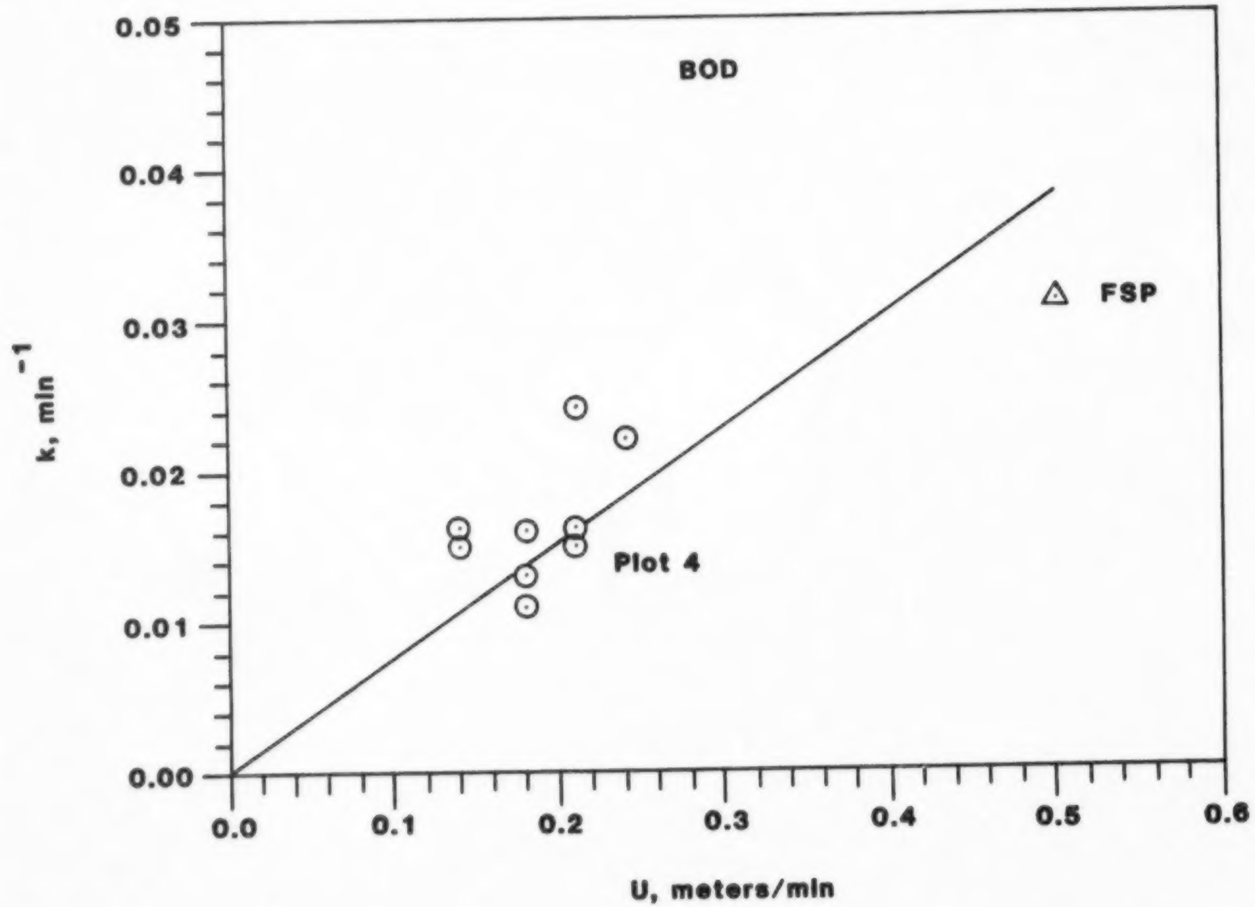

Figure 34. Dependence of Mass Transfer Coefficient on Velocity for BOD of Plot 4.

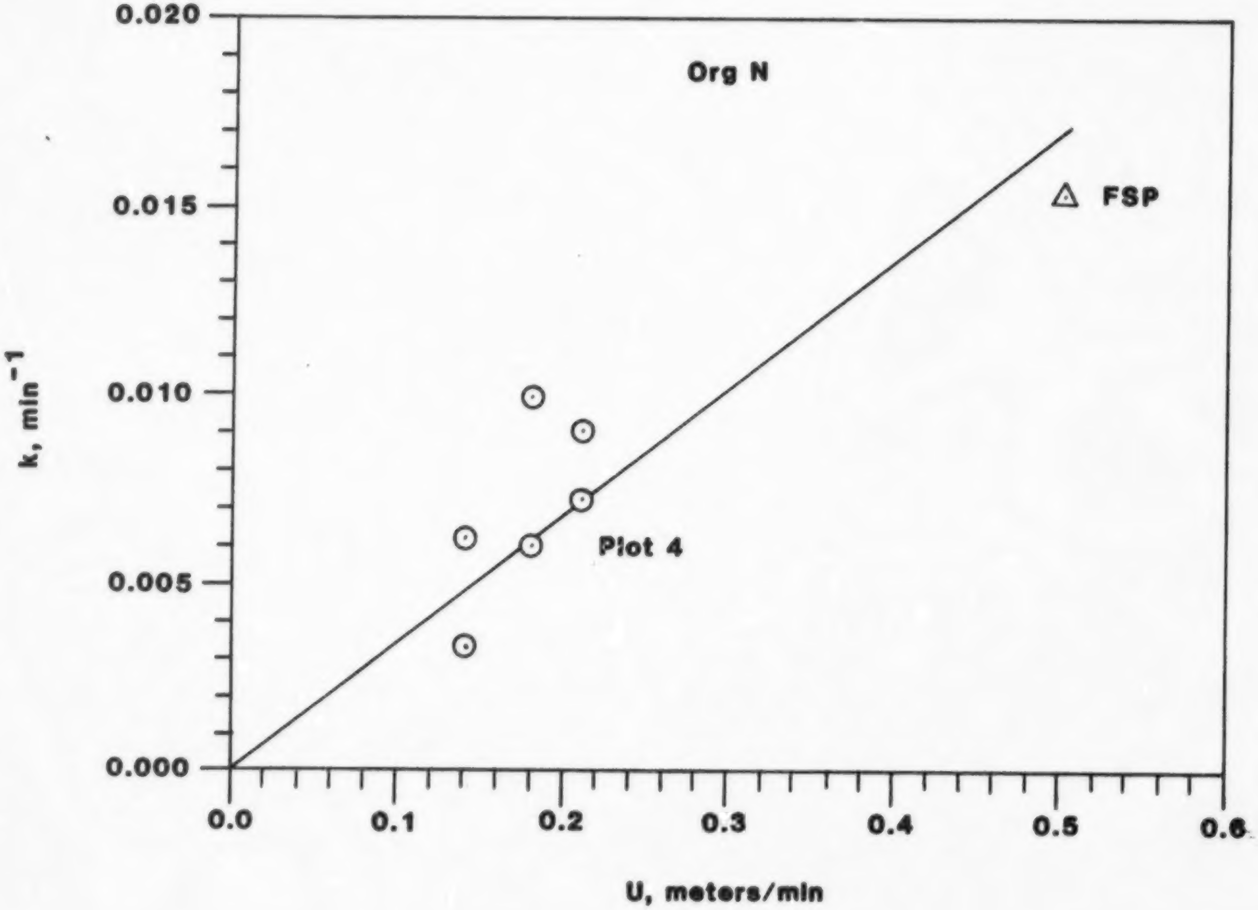

Figure 35. Dependence of Mass Transfer Coefficient on Velocity for Org-N of Plot 4.

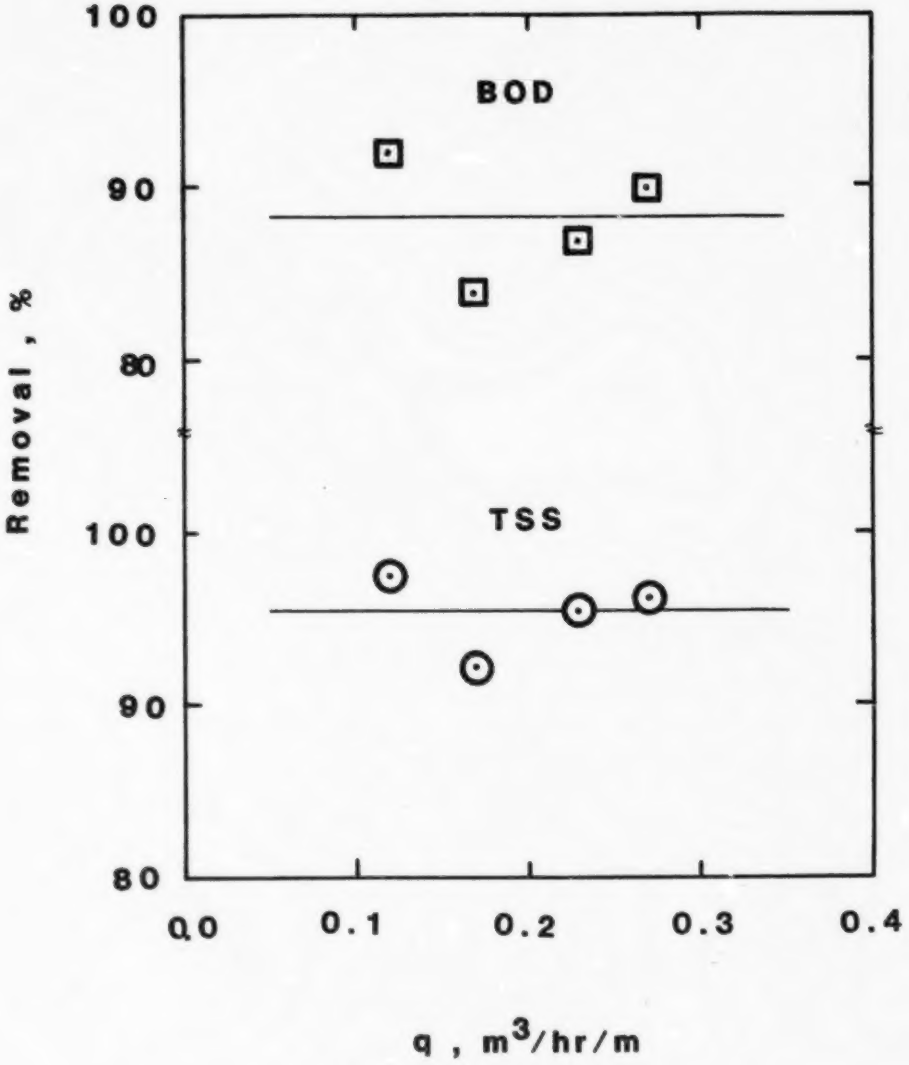

Figure 36. Dependance of TSS and BOD Removal Efficiencies on Pumping Rate.

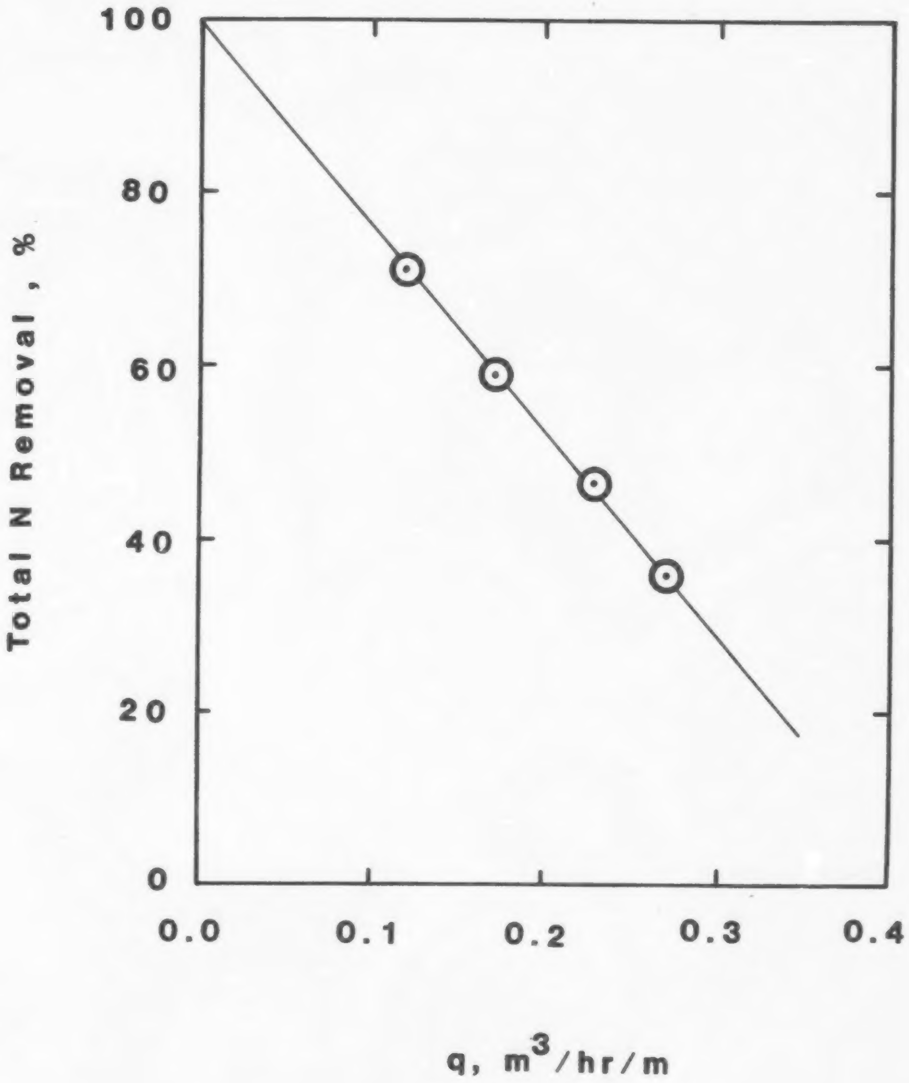

Figure 37. Dependence of Total N Removal Efficiency on Pumping Rate.

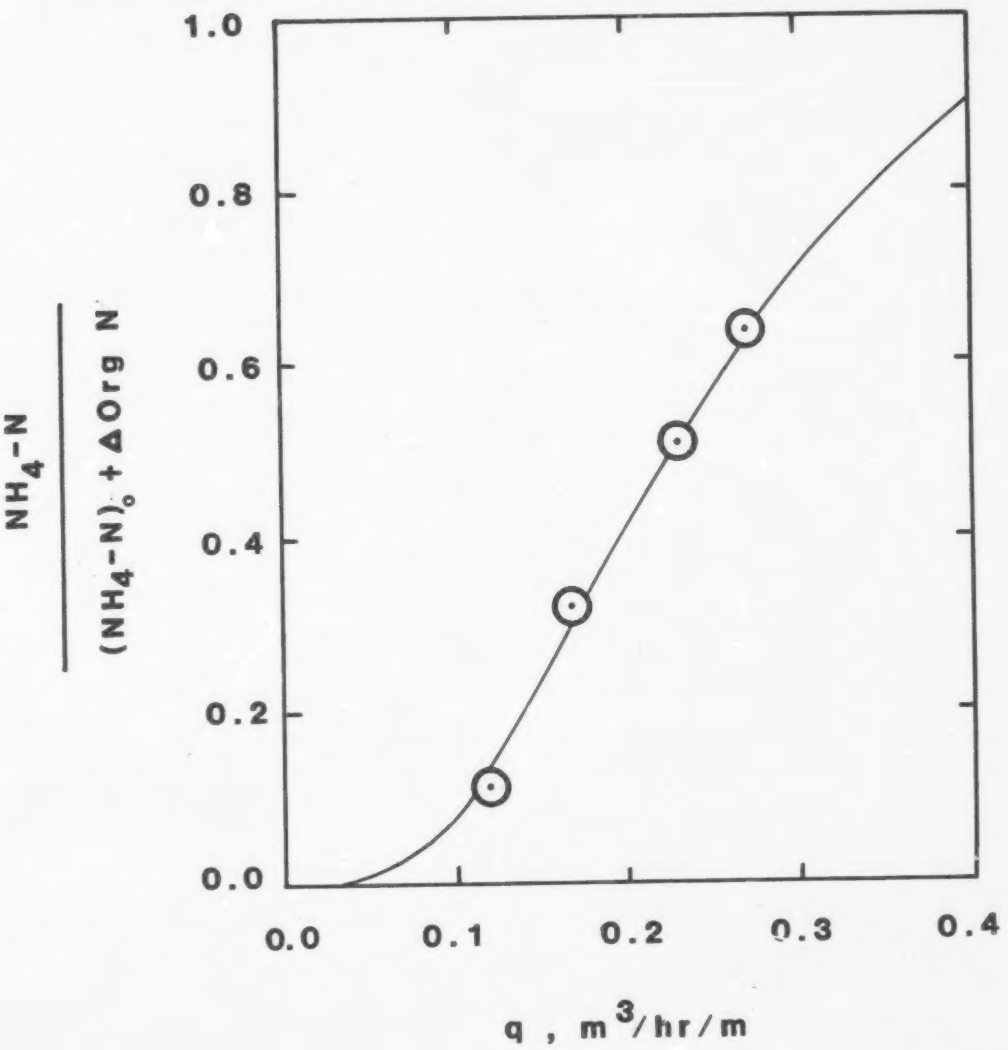

Figure 38. Dependence of Nitrification Efficiency on Pumping Rate.

complete nutrification of available NH_4. It appears that fractional nitrification decreased with increased q. We speculate that nitrification occurred in the flowing liquid, and that increased q led to decreased detention time on the field. Hence, the reduction in nitrification. Based upon this premise, N reduction with overland flow is limited by nitrification.

QUALITY ASSURANCE PROGRAM

An extensive quality assurance program was conducted throughout the course of this study. It was a requirement of the EPA grant to provide confidence in the data collected under the project. The program consisted of (1) sample handling, (2) analytical procedures, (3) data management and (4) statistical analysis. Each of these will be discussed. Data for quality assurance are included in Appendix D.

Sample Handling

Grab samples were collected on site in polyethylene containers. Containers were rinsed with samples before filling. Readings of pH were taken at the site, following calibration of the pH meter at 7.0 and 10.0 in the lab. An aliquot of each sample was filtered for later measurement of ortho P. Companion grab samples were collected and acidified with 2 ml of concentrated sulfuric acid per liter of sample and later analyzed for COD, total P and the nitrogen series. All samples were then packed in ice and transported to Gainesville. Upon arrival these were placed in a refrigerator at 4°C. All procedures were performed the following day with the exception of COD and total P, which were completed the second day.

Dissolved oxygen and temperature were measured in place for each sampling point with a YSI Model 58 oxygen unit. The instrument was calibrated on site before each sampling.

Analytical Procedures

The laboratory procedures used are described in Appendix E. With each batch of samples analyzed, procedures discussed in the EPA Handbook for Analytical Quality Control in Water and Wastewater Laboratories (USEPA, 1979), particularly chapter 6, were followed. A variety of tests were run on blanks, standards, spikes and duplicates. Table 17 lists values used for quality assurance standards throughout the study, while Table 18 lists the spikes used. Laboratory procedures were the same as for samples. In addition, EPA quality assurance standards included periodically, several times during the study, split samples submitted to the EPA Lab at Ada, Oklahoma for control checks.

Data Management

All data from field and lab tests were recorded in a bound notebook. The notebook contained only data for this project. Results for each sampling period for samples, blanks, standards and spikes were recorded on a summary sheet and kept on file. Duplicates were submitted to the project officer as a part of each quarterly report.

Statistical Analysis

Basic data on measured values and recoveries are given in Appendix D for standards and spikes. A summary of parameter values for standards and spikes is shown in Tables 19 and 20. One measure of quality control is the coefficient of variation, defined as the ratio of standard deviation to the average. Results of this study (Tables 19 and 20) may be compared to those for a set of EPA quality assurance standards (Table 21). Results for this project compare favorably to those of the EPA program.

Recovery data are plotted in Figures 39 - 48. Results for the chloride standard are shown in Figure 30. The center line represents the average recovery (99 percent) for the study. Upper and lower lines are two standard deviations (4 percent) from the average, and encompass the 95 percent confidence interval. Figure 31 shows similar results for the chloride spike. Such charts reveal any trends in average and scatter that may be present. No significant upward or downward trends are apparent for these graphs. Fluctuations about the average are also consistent. Standard deviations are noticeably higher for spikes over standards. This is expected from the nature of spikes.

Early in 1982 a problem with the phosphorous procedure appeared, viz., for some samples orthophosphate exceeded total phosphate. Through repetitive analysis and splitting of samples with the EPA Lab in Ada revealed that the problem was with orthophosphate. Ultimately cross contamination of volumetric flasks used in the ortho procedure was identified. Subsequently, new flasks were dedicated to phosphorous chemistry only and the problem was eliminated. Even acid washing and multiple rinses of deionized water failed to decontaminate the old flasks. Split sampling with the EPA Lab helped identify and resolve the problem. Such is the value of a continuing quality assurance program.

Table 17. Quality Assurance Standards.

Date	Sample	EC	Cl	BOD	NH_4-N	TKN	TP	TSS
		µmho/cm	----------mg/l----------					
1-12-82	1	714	175	-	-	2.0	5.0	-
1-19	2	"	"	-	1.0	"	"	-
1-25	3	"	"	-	"	"	"	-
2-1	4	"	"	-	"	"	"	-
2-15	5	"	"	-	2.0	"	"	-
2-22	6	"	"	-	"	"	"	-
3-8	7	"	"	200	"	"	"	-
3-15	8	"	"	"	-	-	-	-
4-4	9	"	"	"	"	"	"	-
4-14	10	"	"	"	"	"	"	-
4-20	11	"	"	"	"	"	"	-
4-26	12	"	"	"	"	"	"	-
5-3	13	"	"	"	"	"	"	-
5-10	14	"	"	"	5.0	5.0	"	-
5-18	15	"	"	"	"	"	"	-
5-25	16	"	"	"	"	"	"	-
6-15	17	"	"	"	"	"	"	-
6-22	18	"	"	"	"	"	"	-
7-14	19	"	"	"	"	"	"	-
7-27	20	"	"	"	"	"	"	-

Table 17. Quality Assurance Standards (cont'd.).

Date	Sample	EC	Cl	BOD	NH_4-N	TKN	TP	TSS
		µmho/cm	---mg/l---					
8-10	21	"	"	"	"	"	"	-
8-24	22	"	"	"	"	"	"	-
10-6	23	"	"	"	"	"	"	-
10-12	24	"	"	"	"	"	"	-
10-26	25	"	"	"	"	"	"	-
11-2-82	26	714	175	200	5.0	5.0	5.0	-
11-16	27	"	"	"	"	"	"	-
11-30	28	"	"	"	"	"	"	-
12-14	29	"	"	"	"	"	"	-
12-28	30	"	"	"	"	"	"	-
1-11-83	"	"	"	"	"	"	"	-
1-25	32	"	"	"	"	"	"	-
2-8	33	"	"	"	"	"	"	-
2-22	34	"	"	"	"	"	"	-
3-8	35	"	"	"	"	"	"	-
3-22	36	"	"	"	"	"	"	-
4-5	37	"	"	"	"	"	"	-
5-3	38	"	"	"	10.0	10.0	"	-
5-17	39	"	"	"	"	"	10.0	-
5-31	40	"	"	"	5.0	"	"	-
6-14	41	"	"	"	"	"	"	-
7-5	42	"	"	"	"	"	"	-
7-19	43	"	"	"	"	"	"	-
8-2	44	"	"	"	"	5.0	"	-
8-16	45	"	"	"	"	"	"	30
8-29	46	"	"	86	"	"	"	"
9-13	47	"	"	200	"	"	"	-
11-8	48	"	"	"	-	"	"	-

Table 18. Quality Assurance Spikes.

Date	Sample	EC	Cl	COD	NO_3-N	NH_4-N	TKN	Ortho P	TP
		µmho/cm	----------mg/l----------						
1-12-82	1	714	175	-	1.0	1.0	1.0	10.0	10.0
1-19	2	"	"	50	"	"	2.0	"	"
1-25	3	"	"	"	2.0	"	"	"	"
2-1	4	"	"	"	"	"	"	"	"
2-15	5	"	"	"	"	"	"	"	"
2-22	6	"	"	"	"	2.0	"	"	"
3-8	7	"	"	"	"	"	"	"	"
3-15	8	"	"	"	"	"	"	"	"
4-4	9	"	"	"	"	1.0	1.0	5.0	5.0
4-14	10	"	"	"	1.0	"	"	"	"
4-20	11	"	"	"	"	"	"	"	"
4-26	12	"	"	"	"	"	"	"	"
5-3	13	"	"	"	"	"	"	"	"
5-10	14	"	"	"	"	5.0	5.0	"	"
5-18	15	"	"	"	"	"	"	"	"
5-25	16	"	"	"	"	"	"	"	"
6-15	17	"	"	"	"	"	"	"	"
6-22	18	"	"	"	"	"	"	"	"
7-14	19	"	"	"	"	"	"	"	"
7-27	20	"	"	"	"	"	"	"	"
8-10	21	"	"	"	"	"	"	"	"
8-24	22	"	"	"	"	"	"	"	"
10-6	23	"	"	"	"	"	"	"	"
10-12	24	"	"	"	"	"	"	"	"
10-26	25	"	"	"	"	"	"	"	"

Table 18. Quality Assurance Spikes (cont'd.).

Date	Sample	EC	Cl	COD	NO_3-N	NH_4-N	TKN	Ortho P	TP
		µmho/cm	mg/l						
11-2-82	26	714	175	50	1.0	5.0	5.0	5.0	5.0
11-16	27	"	"	"	"	"	"	"	"
11-30	28	"	"	"	"	"	"	"	"
12-14	29	"	"	"	"	"	"	"	"
12-28	30	"	"	"	"	"	"	"	"
1-11-83	31	"	"	"	"	"	"	"	"
1-25	32	"	"	"	"	"	"	"	"
2-8	33	"	"	"	"	"	"	"	"
2-22	34	"	"	"	"	"	"	"	"
3-8	35	"	"	"	"	"	"	"	"
3-22	36	"	"	"	"	"	"	"	"
4-5	37	"	"	"	"	"	"	"	"
5-3	38	"	"	"	"	"	"	"	"
5-17	39	"	"	"	"	"	"	"	"
5-31	40	"	"	"	"	"	"	"	"
6-14	41	"	"	"	"	"	"	"	"
7-5	42	"	"	"	"	"	"	"	"
7-19	43	"	"	"	"	"	"	"	"
8-2	44	"	"	"	"	"	"	"	"
8-16	45	"	"	"	1.5	"	"	"	"
8-29	46	"	"	100	2.0	"	"	"	"
9-13	47	"	"	50	1.0	"	"	"	"
11-8	48	"	"	"	"	"	"	"	"

Table 19. Statistics For Quality Assurance Standards.

Parameter	Avg.	Std. Dev.	$\frac{\text{Std. Dev.}}{\text{Avg.}}$
Cl	99	1.	0.01
TSS	30	0.5	0.02
BOD	101	6.	0.06
NH_4-N	99	5.	0.05
TKN	105	9.	0.09
Total P	100	1	0.01

Table 20. Statistics For Quality Assurance Spikes.

Parameter	Avg.	Std. Dev.	$\frac{\text{Std. Dev.}}{\text{Avg.}}$
Cl	101	4	0.04
COD	96	17	0.18
NO_3-N	94	15	0.16
NH_4-N	97	7	0.07
TKN	101	14	0.14
Ortho P	97	16	0.16
Total P	98	7	0.07

Table 21. Statistics For EPA Quality Assurance Standards.

Parameter	Std.	Avg.	Std. Dev.	$\frac{\text{Std. Dev.}}{\text{Avg.}}$
TSS	35.	30.3	2.15	0.071
BOD	-	86.	11.	0.13
COD	156.	150.	9.	0.06
NO_3-N	1.43	1.42	0.065	0.046
NH_4-N	1.90	1.90-	0.11	0.058
TKN	5.28	5.18	0.37	0.071
Ortho P	0.35	0.35	0.01	0.03
Total P	1.37	1.40	0.06	0.04

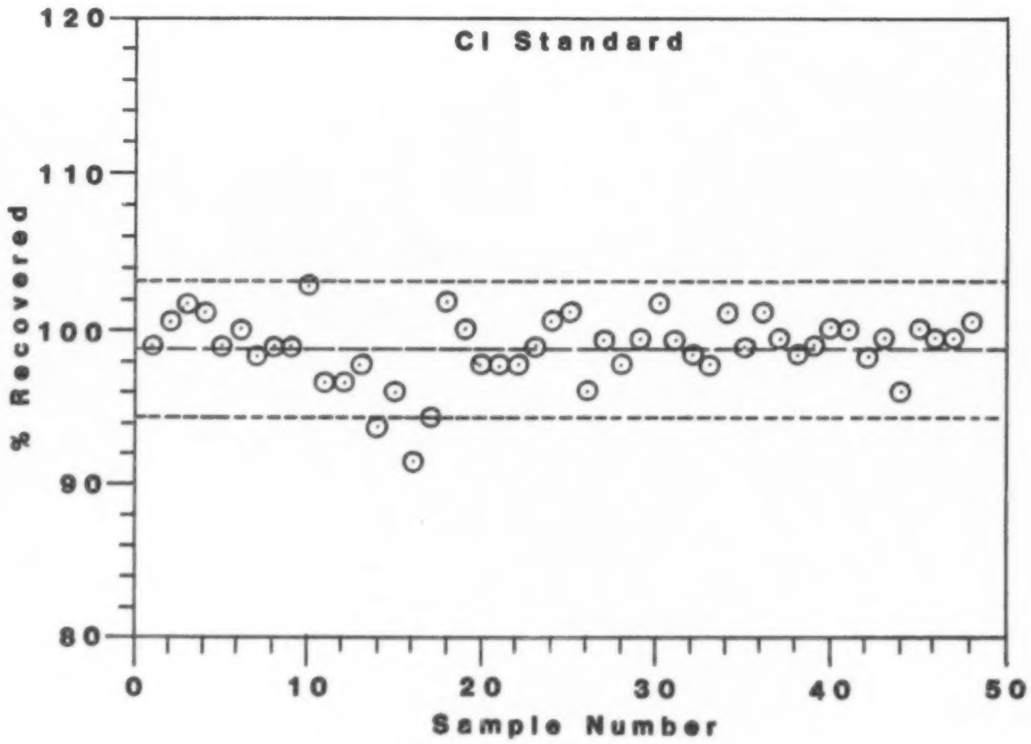

Figure 39. Quality Assurance Plot for Chloride Standard.

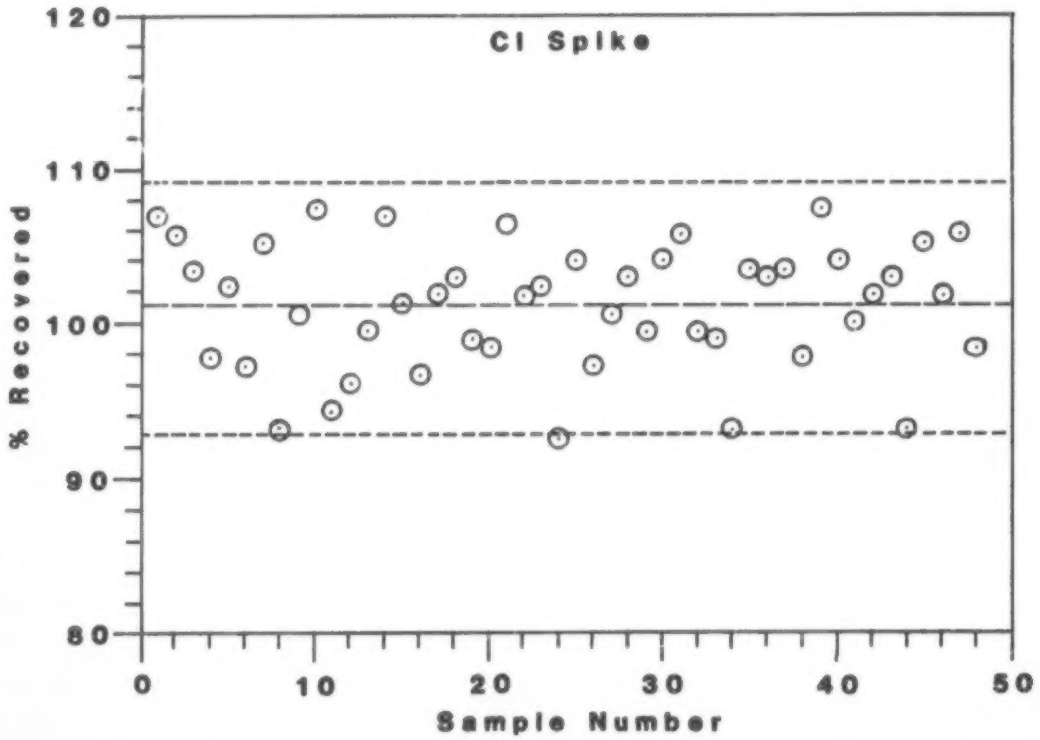

Figure 40. Quality Assurance Plot for Chloride Spike.

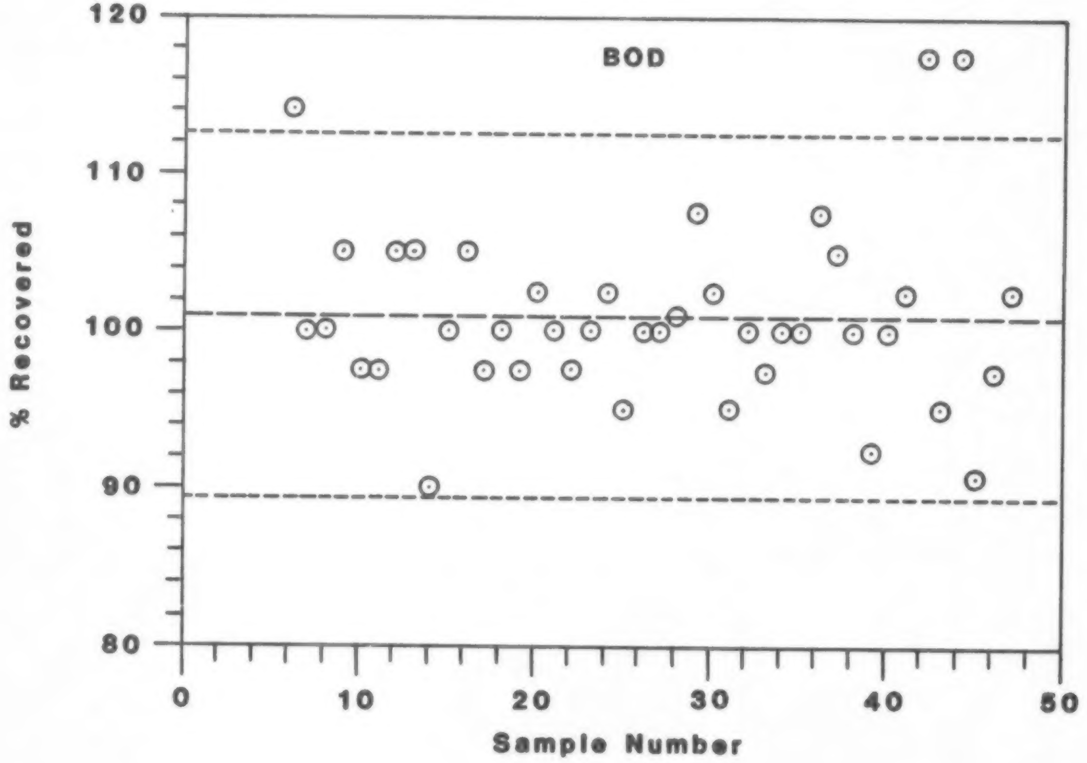

Figure 41. Quality Assurance Plot for BOD.

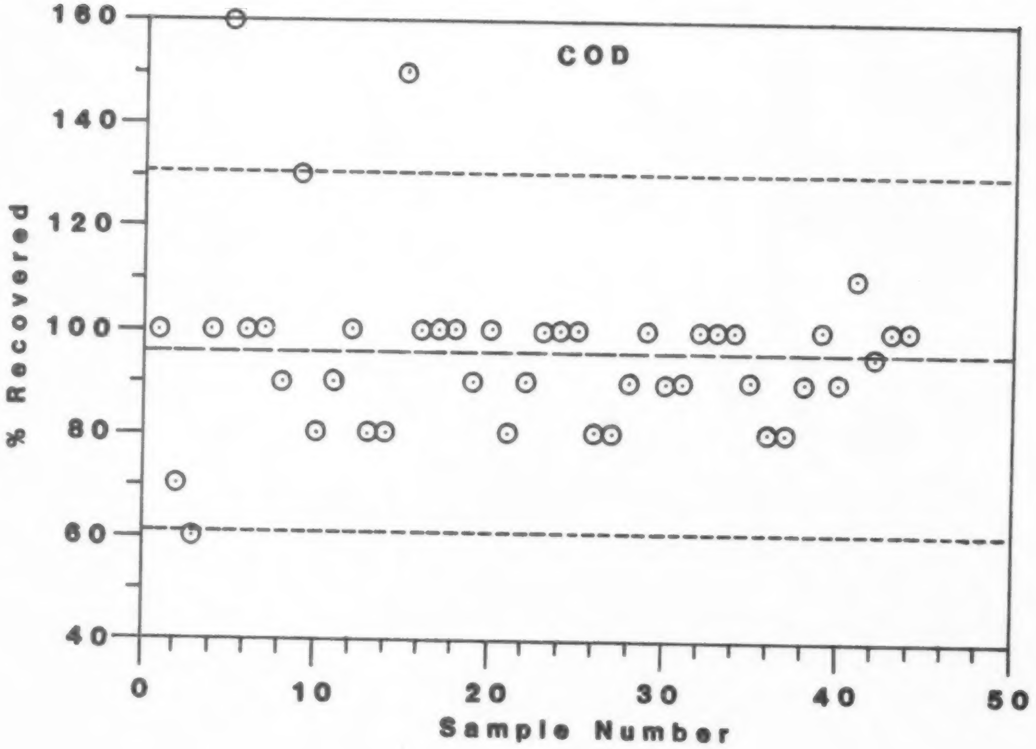

Figure 42. Quality Assurance Plot for COD.

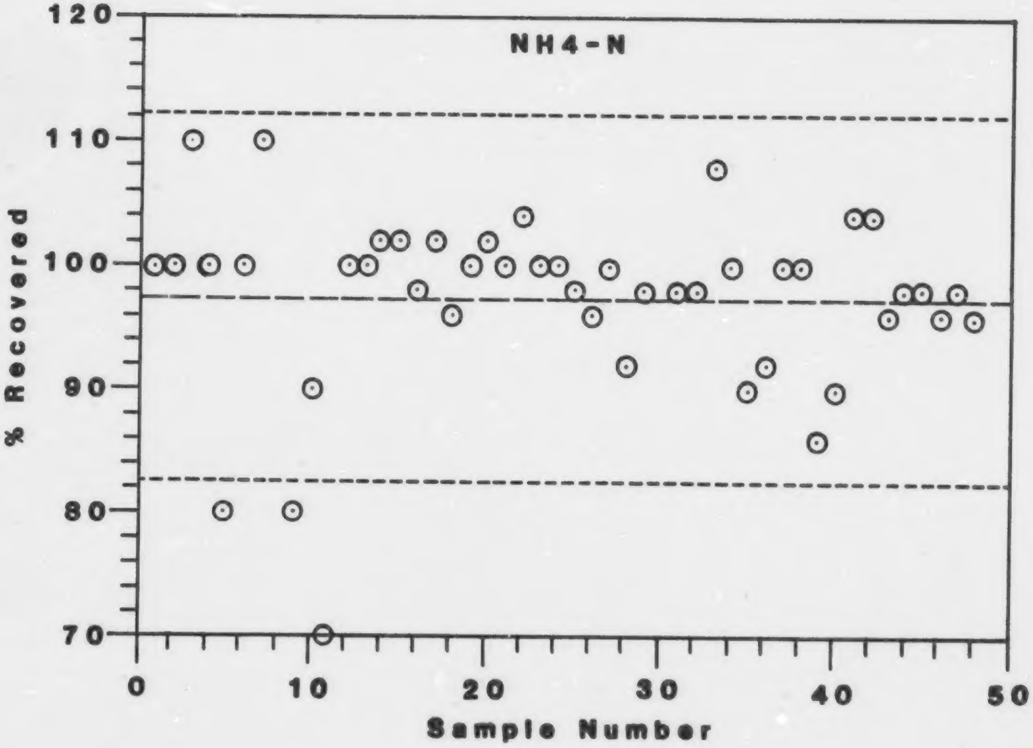

Figure 43. Quality Assurance Plot for NH_4.

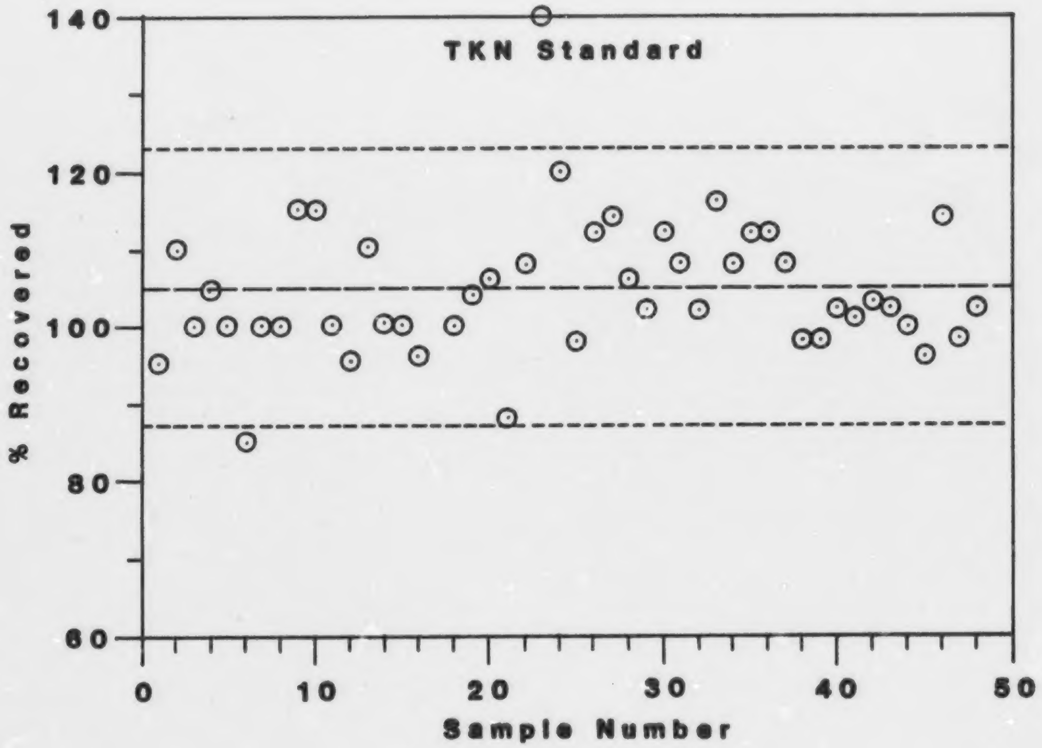

Figure 44. Quality Assurance Plot for TKN Standard.

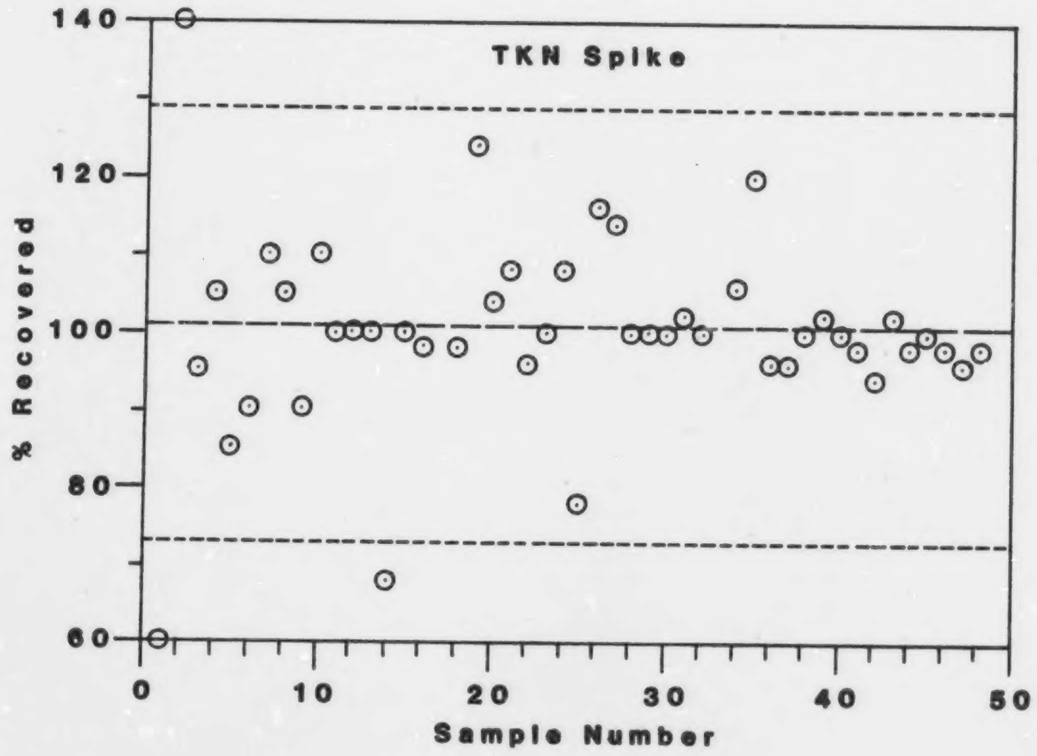

Figure 45. Quality Assurance Plot for TKN Spike.

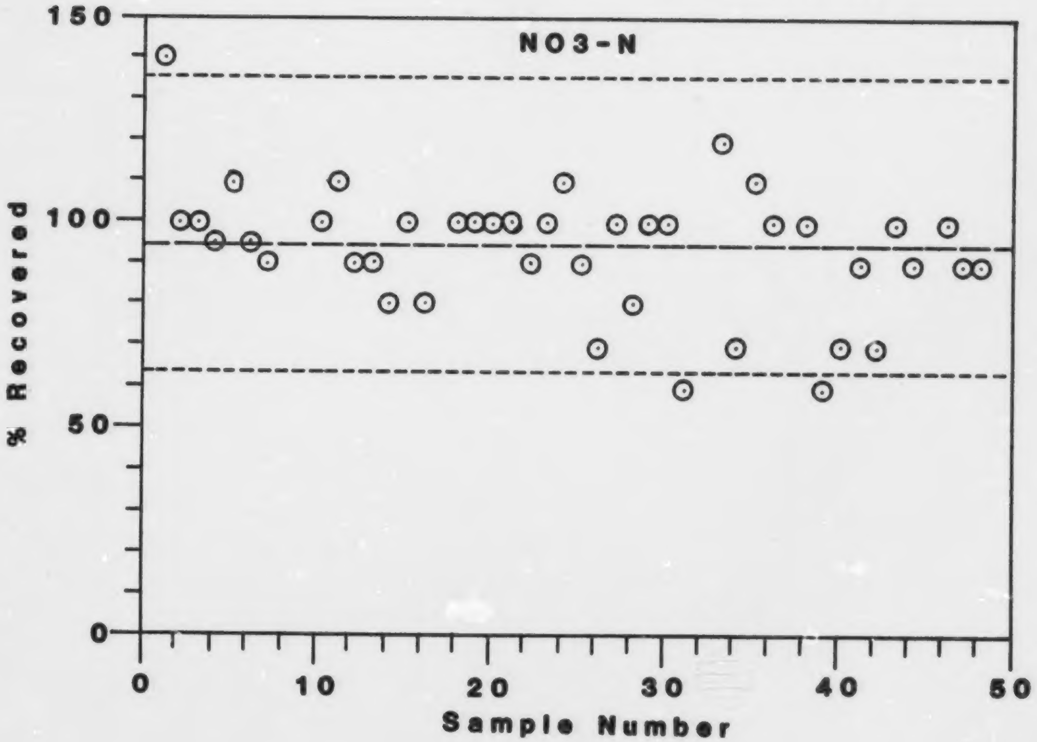

Figure 46. Quality Assurance Plot for NO_3.

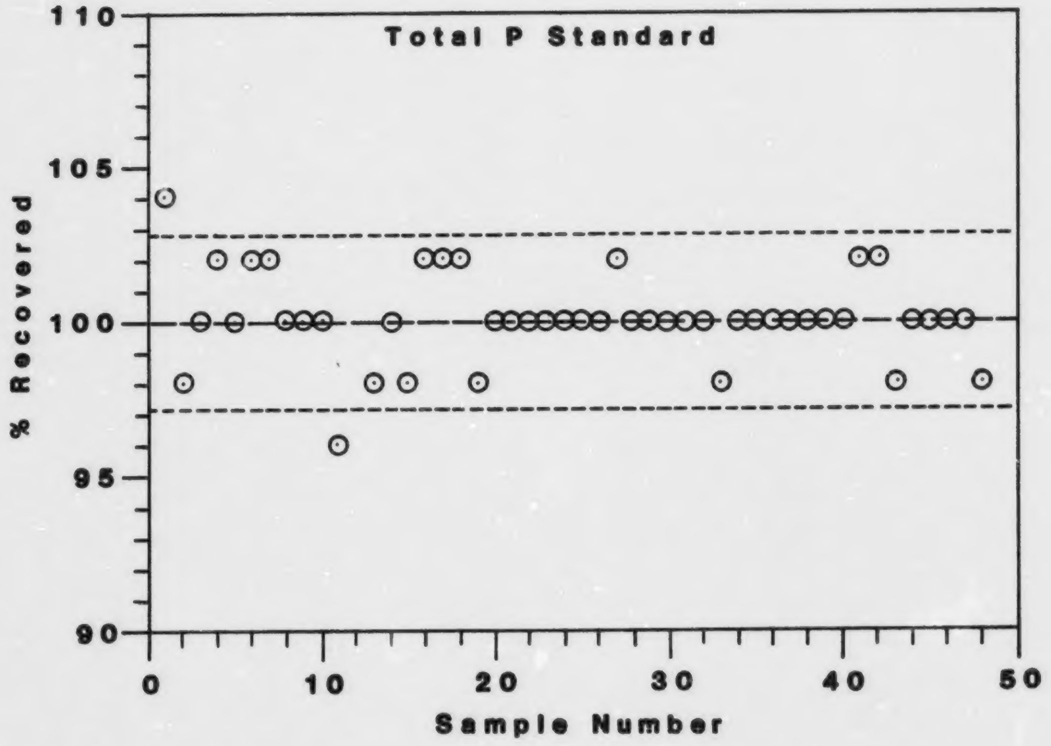

Figure 47. Quality Assurance Plot for Total Phosphorus Standard.

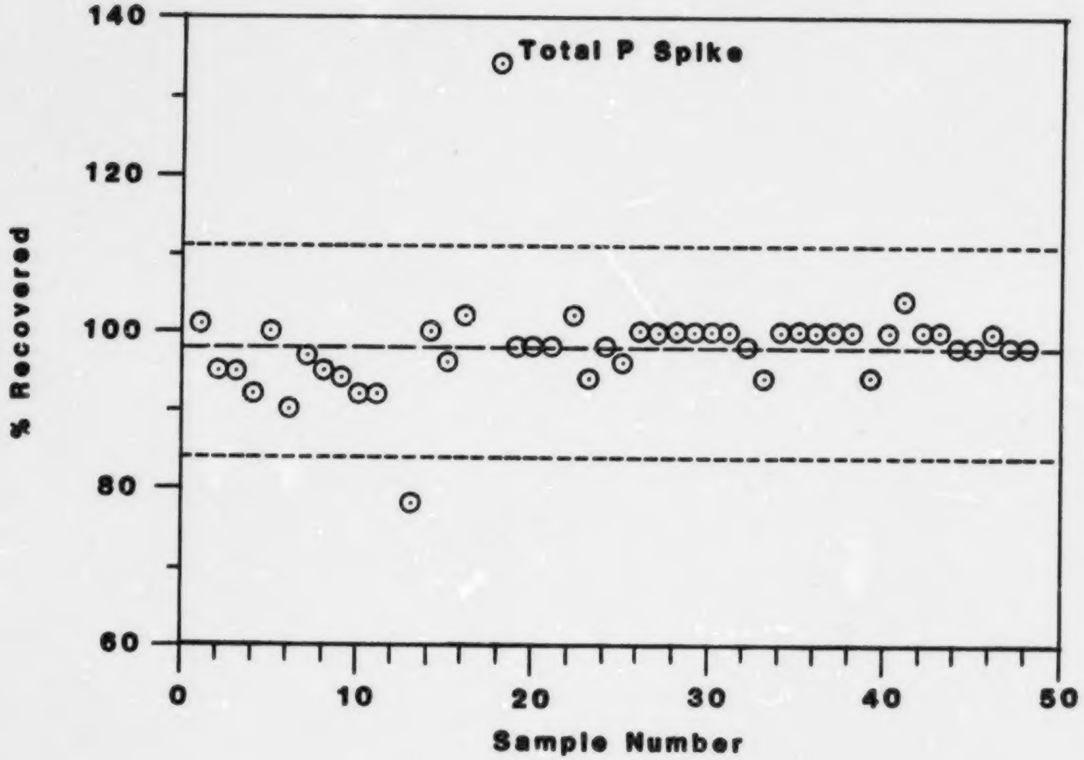

Figure 48. Quality Assurance Plot for Total Phosphorus Spike.

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APPENDIX A

DATA FOR FIELD AND STREAM STUDY

Table A-1. Spray Field Study Data For 4-14-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		8.4	8.0	8.0	6.7	6.7
EC	umho/cm	983.	830.	790.	214.	209.
Cl	mg/l	156.	148.	161.	4.	37.
Turbidity	ntu	90.	7.0	1.3	4.0	4.2
BOD	mg/l	137.	12.	2.8	0.7	0.9
COD	mg/l	245.	35.	25.	15.	30.
NO_3-N	mg/l	0.2	0.8	0.1	0.5	0.5
Org-N	mg/l	5.4	2.5	1.4	1.0	0.8
NH_4-N	mg/l	19.7	1.3	0.2	0.2	0.2
TKN-N	mg/l	25.1	3.8	1.6	1.2	1.0
TN	mg/l	25.3	4.6	1.7	1.7	1.5
Ortho-P	mg/l	-	-	-	-	-
Total-P	mg/l	7.8	6.0	3.4	0.11	0.69
TSS	mg/l	135.	14.	6.8	0.9	1.6
DO	mg/l	-	8.2	8.5	-	-

Table A-2. Spray Field Study Data For 4-20-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.4	7.9	7.8	6.1	6.6
EC	umho/cm	1090.	910.	906.	70.	141.
Cl	mg/l	172.	165.	174.	7.	21.
Turbidity	ntu	130.	8.2	1.9	4.5	3.2
BOD	mg/l	162.	10.	2.5	1.7	1.7
COD	mg/l	390.	25.	35.	10.	10.
NO_3-N	mg/l	0.1	0.3	0.1	0.8	0.7
Org-N	mg/l	15.8	1.9	1.7	0.9	0.8
NH_4-N	mg/l	13.0	2.5	0.0	0.0	0.0
TKN-N	mg/l	28.8	4.4	1.7	0.9	0.8
TN	mg/l	28.9	4.7	1.8	1.7	1.5
Ortho-P	mg/l	-	-	-	-	-
Total-P	mg/l	12.3	7.4	5.2	0.00	0.35
TSS	mg/l	125.	15.	4.4	-	1.8
DO	mg/l	-	6.2	4.6	7.0	5.0

TABLE A-3. Spray Field Study Data For 4-26-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.4	7.7	7.7	5.4	6.4
EC	umho/cm	1080.	970.	725.	57.	110.
Cl	mg/l	159.	160.	120.	0.	11.
Turbidity	ntu	130.	8.4	2.3	4.4	8.2
BOD	mg/l	162.	8.4	2.1	0.7	1.2
COD	mg/l	375.	30.	40.	30.	20.
NO_3-N	mg/l	0.1	0.4	0.1	0.5	0.4
Org-N	mg/l	16.8	2.2	1.5	0.6	0.6
NH_4-N	mg/l	20.2	2.4	0.3	0.2	0.4
TKN-N	mg/l	37.0	4.6	1.8	0.8	1.0
TN	mg/l	37.1	5.0	1.9	1.3	1.4
Ortho-P	mg/l	-	-	-	-	-
Total-P	mg/l	-	-	-	-	-
TSS	mg/l	164.	12.	5.7	0.9	4.5
DO	mg/l	-	5.2	5.4	6.1	5.9

Table A-4. Spray Field Study Data For 5-3-82.

Parameter		Sample			
	Raw	Pond	Runoff	Upstream	Downstream
pH	7.5	8.7	7.9	5.9	6.3
EC umho/cm	1155.	940.	850.	61.	104.
Cl mg/l	183.	167.	153.	5.	14.
Turbidity ntu	92.	28.	3.5	1.2	3.6
BOD mg/l	130.	15.	8.2	7.3	5.5
COD mg/l	360.	80.	35.	20.	0.0
NO_3-N mg/l	0.1	0.2	0.1	0.9	0.7
Org-N mg/l	16.8	6.6	2.6	0.9	1.2
NH_4-N mg/l	23.0	2.5	0.4	0.2	0.2
TKN-N mg/l	39.8	9.1	3.0	1.1	1.4
TN mg/l	39.9	9.3	3.1	2.0	2.1
Ortho-P mg/l	8.5	7.0	5.7	0.02	0.37
Total-P mg/l	10.4	8.3	5.3	0.19	0.32
TSS mg/l	90.	45.	7.8	0.6	1.5
DO mg/l	-	16.6	8.2	7.3	5.5

Table A-5. Spray Field Study Data For 5-10-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.4	9.3	7.5	5.8	6.1
EC	umho/cm	1185.	984.	990.	72.	104.
Cl	mg/l	165.	168.	175.	5.	12.
Turbidity	ntu	120.	55.	3.8	1.0	2.8
BOD	mg/l	145.	21.	3.5	1.0	0.8
COD	mg/l	420.	175.	65.	30.	35.
NO_3-N	mg/l	0.0	0.6	0.1	1.0	0.6
Org-N	mg/l	1.0	5.6	1.3	0.4	0.4
NH_4-N	mg/l	23.0	3.3	0.5	0.0	0.4
TKN-N	mg/l	24.0	8.9	1.8	0.4	0.8
TN	mg/l	24.0	9.5	1.9	1.4	1.4
Ortho-P	mg/l	6.0	4.4	3.5	0.01	0.20
Total-P	mg/l	10.9	7.6	4.0	0.02	0.47
TSS	mg/l	106.	63.	11.	0.5	0.6
DO	mg/l	-	18.5	7.2	7.6	5.1

Table A-6. Spray Field Study Data For 5-18-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.5	9.0	7.6	6.1	6.2
EC	umho/cm	1200.	1130.	1230.	68.	123.
Cl	mg/l	175.	191.	244.	6.	17.
Turbidity	ntu	120.	28.	2.1	1.0	3.5
BOD	mg/l	140.	12.	1.8	0.5	0.7
COD	mg/l	360.	70.	105.	30.	40.
NO_3-N	mg/l	0.0	0.2	0.1	1.3	0.5
Org-N	mg/l	23.3	2.6	1.4	0.6	0.5
NH_4-N	mg/l	11.2	7.7	0.4	0.0	0.1
TKN-N	mg/l	34.5	10.3	1.8	0.6	0.6
TN	mg/l	34.5	10.5	1.9	1.9	1.1
Ortho-P	mg/l	7.1	5.7	2.5	0.06	0.26
Total-P	mg/l	9.8	6.7	2.5	0.05	0.35
TSS	mg/l	119.	34.	4.0	0.6	3.4
DO	mg/l	-	15.7	3.5	6.3	3.5

Table A-7. Spray Field Study Data For 5-25-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.5	8.4	7.4	7.2	6.3
EC	umho/cm	1300.	1100.	1092.	68.	275.
Cl	mg/l	200.	200.	210.	8.	51.
Turbidity	ntu	100.	28.	2.8	1.2	3.1
BOD	mg/l	125.	15.	2.5	1.1	1.1
COD	mg/l	305.	80.	50.	15.	20.
NO_3-N	mg/l	0.0	0.2	0.2	1.3	0.6
Org-N	mg/l	9.9	4.0	0.1	0.6	1.1
NH_4-N	mg/l	32.6	2.2	1.5	0.1	0.0
TKN-N	mg/l	42.5	6.2	1.6	0.7	1.1
TN	mg/l	42.5	6.4	1.8	2.0	1.7
Ortho-P	mg/l	6.4	6.4	4.6	0.33	0.84
Total-P	mg/l	8.3	7.8	4.9	0.90	0.94
TSS	mg/l	100.	44.	4.8	0.9	2.2
DO	mg/l	-	12.2	3.5	6.6	3.5

Table A-8. Spray Field Study Data For 6-15-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.3	9.0	7.4	6.5	6.3
EC	umho/cm	1145.	1018.	1093.	67.	326.
Cl	mg/l	193.	194.	225.	7.	57.
Turbidity	ntu	103.	21.	3.5	1.2	3.3
BOD	mg/l	135.	11.	1.6	1.0	1.0
COD	mg/l	260.	45.	35.	5.	15.
NO_3-N	mg/l	0.1	0.7	0.1	1.1	0.6
Org-N	mg/l	4.3	3.4	1.3	0.7	1.1
NH_4-N	mg/l	18.8	0.3	0.2	0.1	0.1
TKN-N	mg/l	23.1	3.7	1.5	0.8	1.2
TN	mg/l	23.2	4.4	1.6	1.9	1.8
Ortho-P	mg/l	5.2	4.7	1.5	0.01	0.59
Total-P	mg/l	7.7	5.9	2.2	0.10	0.72
TSS	mg/l	128.	28.	6.4	0.5	1.9
DO	mg/l	-	14.3	5.0	5.9	3.0

Table A-9. Spray Field Study Data For 6-22-82.

Parameter		Sample			
	Raw	Pond	Runoff	Upstream	Downstream
pH	7.2	7.3	7.1	5.7	6.1
EC umho/cm	1130.	1068.	1140	67.	258.
Cl mg/l	187.	185.	217.	13.	71.
Turbidity ntu	110.	10.	1.3	1.2	3.1
BOD mg/l	128.	6.3	1.3	0.6	0.6
COD mg/l	285.	30.	40.	15.	25.
NO_3-N mg/l	0.2	0.6	0.1	1.0	0.5
Org-N mg/l	10.8	2.3	1.4	0.9	0.8
NH_4-N mg/l	22.7	2.5	0.3	0.1	0.3
TKN-N mg/l	33.5	4.8	1.7	1.0	1.1
TN mg/l	33.7	5.4	1.8	2.0	1.6
Ortho-P mg/l	5.0	6.4	7.6	0.03	0.68
Total-P mg/l	7.0	7.3	8.1	0.03	0.72
TSS mg/l	143.	16.	3.1	0.8	2.0
DO mg/l	-	6.3	4.8	6.2	3.3

Table A-10. Spray Field Study Data For 7-14-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.4	8.9	7.3	5.9	6.1
EC	umho/cm	1150.	995.	915.	59.	162.
Cl	mg/l	176.	192.	171.	9.	28.
Turbidity	ntu	125.	45.	4.0	1.9	3.8
BOD	mg/l	150.	15.	2.6	0.7	0.6
COD	mg/l	275.	75.	40.	20.	20.
NO_3-N	mg/l	0.0	0.1	0.1	0.7	0.6
Org-N	mg/l	10.3	3.9	2.1	0.8	1.0
NH_4-N	mg/l	20.7	0.1	0.1	0.1	0.2
TKN-N	mg/l	31.0	4.0	2.2	0.9	1.2
TN	mg/l	31.0	4.1	2.3	1.6	1.8
Ortho-P	mg/l	6.2	3.4	3.7	0.02	0.34
Total-P	mg/l	10.1	5.7	3.7	0.03	0.53
TSS	mg/l	134.	43.	6.0	0.8	1.4
DO	mg/l	-	10.0	3.2	6.2	5.4

Table A-11. Spray Field Study Data For 8-10-82.

Parameter		Sample				
		Raw	Pond	Runoff	Upstream	Downstream
pH		7.0	8.1	7.2	5.4	6.3
EC	umho/cm	740.	699.	637.	61.	148.
Cl	mg/l	110.	116.	110.	1.	19.
Turbidity	ntu	65.	13.	1.2	5.5	5.8
BOD	mg/l	78.	11.	1.2	0.5	0.6
COD	mg/l	205.	35.	25.	45.	35.
NO_3-N	mg/l	0.0	0.6	0.0	0.3	0.3
Org-N	mg/l	4.0	2.9	1.5	1.7	1.2
NH_4-N	mg/l	12.1	0.8	0.0	0.0	0.0
TKN-N	mg/l	16.1	3.7	1.5	1.7	1.2
TN	mg/l	16.1	4.3	1.5	2.0	1.5
Ortho-P	mg/l	3.4	3.8	1.7	0.00	0.33
Total-P	mg/l	5.7	4.1	1.6	0.03	0.34
TSS	mg/l	79.	20.	1.2	1.3	1.5
DO	mg/l	-	10.0	5.6	6.8	6.3

APPENDIX B

DATA FOR PLOT STUDIES

Table B- 1. Data For Plot Study For 1-12-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		-	-	7.8	7.8	7.8	7.9	7.8	7.5	-	7.0 10.0	-
EC	umho/cm	-	-	780.	795.	793.	822.	795.	750.	0.68	725.	1450.
Cl	mg/l	-	-	117.	117.	118.	123.	120.	127.	0.0	99.	304.
Turbidity	ntu	-	-	6.6	6.6	3.3	5.9	4.0	2.8	0.0	18.0	-
TSS	mg/l	-	-	8.5	9.4	4.9	6.9	5.9	7.7	0.0	-	-
BOD	mg/l	-	-	6.5	6.7	6.3	10.0	6.1	6.6	0.2	-	-
COD	mg/l	-	-	15.	15.	15.	25.	15.	25.	-	45.	5.
TKN	mg/l	-	-	1.9	2.0	2.5	1.8	2.3	1.8	0.0	1.9	2.5
NH_4-N	mg/l	-	-	0.0	0.0	0.1	0.3	0.2	0.2	0.0	-	1.0
Org N	mg/l	-	-	1.9	2.0	2.4	1.5	2.1	1.6	-	-	-
NO_3-N	mg/l	-	-	1.3	1.4	1.4	1.5	1.7	1.1	0.0	1.0	2.8
TN	mg/l	-	-	3.3	3.4	3.9	3.3	4.0	2.9	-	-	-
Ortho P	mg/l	-	-	7.4	7.2	7.4	7.3	7.1	5.4	-	5.2	17.2
Total P	mg/l	-	-	7.6	7.6	7.4	7.8	7.5	5.5	0.1	5.2	17.7
Temp	°C	-	-	6.	-	6.	6.	6.	6.	-	-	-
DO	mg/l	-	-	-	-	-	-	-	-	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 2. Data For Plot Study For 1-19-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH				7.6	7.5	7.7	7.6	7.7	7.4	-	7.0 10.0	-
EC	umho/cm			725.	715.	698.	725.	718.	674.	0.77	705.	1335.
Cl	mg/l			113.	110.	111.	110.	113.	105.	0.0	176.	297.
Turbidity	ntu			3.8	3.9	2.1	2.4	3.7	21.0	0.1	18.0	-
TSS	mg/l			3.0	4.3	2.1	2.3	2.5	0.6	0.0	-	-
BOD	mg/l			1.5	1.5	2.1	2.4	2.9	1.8	0.5	-	-
COD	mg/l			15.	15.	10.	10.	15.	15.	-	55.	65.
TKN	mg/l			1.9	1.7	1.4	1.5	1.7	1.2	0.3	2.2	4.6
NH_4-N	mg/l			0.3	0.3	0.1	0.1	0.1	0.0	0.0	0.1	1.3
Org N	mg/l			1.6	1.4	1.3	1.4	1.6	1.2	-	-	-
NO_3-N	mg/l			9.2	9.6	9.2	9.6	10.0	7.8	-	1.1	10.4
TN	mg/l			11.1	11.3	10.6	11.1	11.7	9.0	-	-	-
Ortho P	mg/l			5.2	5.4	5.1	5.1	5.2	4.2	-	5.1	14.9
Total P	mg/l			5.3	5.4	5.1	5.1	5.2	4.2	0.1	4.9	14.8
Temp	°C	-	-	-	-	-	-	-	-	-	-	-
DO	mg/l	-	-	-	-	-	-	-	-	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 3. Data For Plot Study For 1-25-82.

Parameter		Sample										
		Raw	Aeration Tank	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		-	7.1	7.7	7.7	8.0	8.4	8.1	7.5	-	7.0 10.0	-
EC	umho/cm	-	970.	928.	936.	882.	910.	909.	870.	0.52	718.	1565.
Cl	mg/l	-	-	168.	170.	158.	167.	164.	159.	0.0	178.	350.
Turbidity	ntu	-	-	6.5	5.9	3.4	3.4	4.5	1.8	0.0	18.0	-
TSS	mg/l	-	270.	13.2	13.6	3.0	6.2	6.4	1.8	0.0	-	-
BOD	mg/l	-	455.	4.6	4.8	5.1	5.3	5.3	2.6	0.2	-	-
COD	mg/l	-	1450.	20.	15.	10.	10.	10.	10.	-	30.	50.
TKN	mg/l	-	-	3.2	3.1	1.4	1.3	1.8	1.0	0.0	2.0	5.0
NH_4-N	mg/l	-	0.6	0.5	0.5	0.0	0.1	0.1	0.1	0.0	1.00	1.4
Org N	mg/l	-	-	2.7	2.6	1.4	1.2	1.7	0.9	-	-	-
NO_3-N	mg/l	-	2.1	2.1	2.0	1.1	1.0	1.8	1.3	-	0.98	4.1
TN	mg/l	-	-	5.3	5.1	2.5	2.3	3.6	2.3	-	-	-
Ortho P	mg/l	-	22.0	8.1	8.1	6.5	8.9	9.0	8.9	-	5.2	17.6
Total P	mg/l	-	37.3	13.2	13.6	6.7	6.3	7.2	6.3	0.1	5.0	17.6
Temp	°C	-	-	15.	-	15.	15.	13.	13.	-	-	-
DO	mg/l	-	-	-	-	9.4	10.7	9.8	8.0	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 4. Data For Plot Study For 2-1-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	-	7.5	7.5	8.0	8.4	8.1	7.4	-	7.0 10.0	-
EC	umho/cm	1115.	-	969.	969.	905.	913.	890.	832.	5.4	710.	1585.
Cl	mg/l	181.	-	177.	182.	170.	172.	176.	155.	0.0	177.	351.
Turbidity	ntu	80.	-	5.9	5.7	3.2	3.7	4.3	1.6	0.0	18.0	-
TSS	mg/l	144.	-	12.6	12.4	7.4	7.7	9.1	2.5	0.0	-	-
BOD	mg/l	-	-	4.4	4.2	5.4	6.1	6.7	2.7	0.4	-	-
COD	mg/l	-	-	20.	10.	15.	15.	15.	15.	-	50.	40.
TKN	mg/l	30.	-	2.7	2.5	1.8	1.6	2.1	1.4	0.1	2.1	4.7
NH_4-N	mg/l	25.6	-	1.0	0.9	0.1	0.1	0.2	0.1	0.0	1.0	1.9
Org N	mg/l	4.4	-	1.7	1.6	1.7	1.5	1.9	1.3	-	-	-
NO_3-N	mg/l	0.2	-	3.4	3.4	2.3	2.5	3.3	1.0	-	1.0	5.3
TN	mg/l	30.2	-	6.1	5.9	4.1	4.1	5.4	2.4	-	-	-
Ortho P	mg/l	-	-	7.1	7.1	7.7	6.4	6.7	5.5	-	4.9	17.1
Total P	mg/l	-	-	8.5	8.3	6.9	6.6	7.1	5.5	0.1	5.1	17.6
Temp	°C	-	-	12.	-	12.	12.	10.	9.	-	-	-
DO	mg/l	-	-	9.3	-	12.5	13.7	12.0	8.8	-	-	
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 5. Data For Plot Study For 2-8-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		-	-	7.5	7.5	-	-	8.3	7.5	-	7.0 10.0	-
EC	umho/cm	-	-	734.	745.	-	-	736.	732.	1.2	715.	1375.
Cl	mg/l	-	-	126.	126.	-	-	128.	123.	0.0	173.	305.
Turbidity	ntu	-	-	8.5	8.9	-	-	5.6	2.1	0.1	17.9	-
TSS	mg/l	-	-	17.4	16.9	-	-	10.1	2.4	-	-	-
BOD	mg/l	-	-	14.0	14.4	-	-	9.3	3.3	-	-	-
COD	mg/l	-	-	65.	50.	-	-	50.	35.	0.0	60.	105.
TKN	mg/l	-	-	3.8	3.8	-	-	2.2	1.1	0.1	1.8	5.5
NH_4-N	mg/l	-	-	1.0	1.0	-	-	0.0	0.0	0.1	1.8	2.3
Org N	mg/l	-	-	2.8	2.8	-	-	2.2	1.1	-	-	-
NO_3-N	mg/l	-	-	3.2	3.2	-	-	3.4	2.0	0.0	-	5.6
TN	mg/l	-	-	7.0	7.0	-	-	5.6	3.1	-	-	-
Ortho P	mg/l	-	-	7.2	7.3	-	-	6.4	6.6	0.0	5.3	10.2
Total P	mg/l	-	-	7.8	7.9	-	-	6.5	6.3	0.1	5.0	9.0
Temp	°C	-	-	-	-	-	-	-	-	-	-	-
DO	mg/l	-	-	-	-	-	-	-	-	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 6. Data For Plot Study For 2-15-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		-	-	7.7	7.7	7.6	8.6	8.7	7.5	-	7.0 10.0	-
EC	umho/cm	-	-	655.	657.	637.	659.	645.	655.	0.5	727.	1345.
Cl	mg/l	-	-	118.	113.	106.	110.	107.	111.	0.0	175.	285.
Turbidity	ntu	-	-	8.1	8.0	4.8	5.4	5.8	2.4	0.0	17.9	-
TSS	mg/l	104.	-	18.	20.	7.6	11.	13.	4.0	-	0.0	-
BOD	mg/l	114.	-	3.7	3.7	4.8	6.4	6.6	2.8	0.2	-	-
COD	mg/l	-	-	35.	35.	40.	50.	40.	35.	0.0	60.	85.
TKN	mg/l	-	-	2.5	2.5	1.3	1.3	1.7	0.8	0.1	2.0	4.2
NH_4-N	mg/l	-	-	0.0	0.1	0.1	0.1	0.0	0.0	0.1	1.6	0.8
Org N	mg/l	-	-	2.5	2.4	1.2	1.2	1.7	0.8	-	-	-
NO_3-N	mg/l	-	-	1.8	1.8	0.4	0.5	1.0	0.0	-	-	4.0
TN	mg/l	-	-	4.3	4.3	1.7	1.8	2.7	0.8	-	-	-
Ortho P	mg/l	-	-	4.6	4.8	5.2	4.5	4.9	4.9	0.0	5.3	15.1
Total P	mg/l	-	-	4.9	5.1	4.1	4.3	5.1	7.1	0.1	5.0	15.0
Temp	°C	-	-	-	-	-	-	-	-	-	-	-
DO	mg/l	-	-	-	-	-	-	-	-	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 7. Data For Plot Study For 2-22-82.

Parameter					Sample						
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.2	-	7.4	7.4	8.1	8.7	8.7	7.7	-	7.0 10.0	-
EC umho/cm	-	-	950.	951.	880.	906.	899.	856.	1.2	731.	1610.
Cl mg/l	-	-	147.	138.	153.	153.	151.	143.	0.0	172.	327.
Turbidity ntu	100.	-	22.	21.	6.2	6.3	8.0	2.5	0.0	18.0	-
TSS mg/l	18.5	-	6.4	7.2	6.0	7.7	-	-	0.0	-	-
BOD mg/l	-	-	-	-	-	-	-	-	-	-	-
COD mg/l	-	-	45.	70.	40.	40.	40.	30.	-	55.	140.
TKN mg/l	-	-	6.0	6.0	2.0	2.2	2.9	1.4	0.0	1.7	7.8
NH_4-N mg/l	-	-	4.5	4.6	0.4	0.5	1.1	0.2	0.2	2.0	6.6
Org N mg/l	-	-	1.5	1.4	1.6	1.7	1.8	1.2	-	-	-
NO_3-N mg/l	-	-	1.8	1.8	1.5	1.5	2.0	1.1	-	-	3.7
TN mg/l	-	-	7.8	7.8	3.5	3.7	4.9	2.5	-	-	-
Ortho P mg/l	-	-	8.7	8.2	6.2	5.5	6.0	5.6	-	5.1	19.2
Total P mg/l	-	-	10.6	9.3	6.2	5.7	6.3	5.7	0.3	5.1	19.0
Temp °C	-	-	19.	-	19.	19.	19.	16.	-	-	-
DO mg/l	-	-	8.6	-	10.0	10.6	11.2	7.5	-	-	-
Q liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 8. Data For Plot Study For 3-1-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.4	-	7.7	7.6	8.6	8.8	8.6	7.3	-	7.0 10.0	-
EC umho/cm	1165.	-	970.	988.	958.	982.	967.	952.	1.2	710.	1600.
Cl mg/l	-	-	174.	161.	163.	163.	161.	157.	0.0	173.	342.
Turbidity ntu	85.	-	4.7	4.6	2.5	3.4	3.3	1.3	0.0	18.1	-
TSS mg/l	98.	-	8.0	7.6	3.6	5.6	4.8	2.0	-	-	-
BOD mg/l	111.	-	2.8	2.8	2.7	3.8	3.6	1.4	-	205.	-
COD mg/l	-	-	30.	30.	30.	40.	40.	25.			
TKN mg/l	-	-	2.5	2.7	1.5	1.6	1.8	1.2	0.0	2.3	4.3
NH_4-N mg/l	-	-	0.8	0.9	0.0	0.2	0.2	0.0	-	1.5	2.4
Org N mg/l	-	-	1.7	1.8	1.5	1.4	1.6	1.2	-	-	-
NO_3-N mg/l	-	-	3.0	-	1.7	1.9	2.4	1.6	-	-	5.0
TN mg/l	-	-	5.5	-	3.2	3.5	4.2	3.8	-	-	-
Ortho P mg/l	-	-	6.2	6.6	5.6	5.6	5.6	5.3	-	5.1	9.8
Total P mg/l	-	-	6.2	6.2	5.4	5.4	5.6	5.1	-	5.0	16.0
Temp °C	-	-	11.	-	11.	11.	11.	11.	-	-	-
DO mg/l	-	-	10.2	-	11.9	12.9	11.8	9.2	-	-	-
Q liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 9. Data For Plot Study For 3-8-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	-	8.7	8.7	9.3	9.5	9.3	8.1	-	7.0 10.0	-
EC	umho/cm	1010.	-	898.	903.	860.	860.	884.	853.	0.48	702.	1590.
Cl	mg/l	-	-	164.	184.	161.	167.	164.	154.	0.0	173.	337.
Turbidity	ntu	75.	-	10.9	10.6	7.6	10.5	10.4	3.8	0.0	18.1	-
TSS	mg/l	88.	-	30.	26.	19.	22.	24.	10.	-	-	-
BOD	mg/l	89.	-	16.	14.	8.4	8.1	8.1	6.8	.5	228.	-
COD	mg/l	-	-	65.	75.	55.	65.	55.	40.	0.0	65.	120.
TKN	mg/l	-	-	3.9	3.9	2.7	2.8	3.0	2.5	0.0	2.0	6.1
NH_4-N	mg/l	-	-	0.1	0.1	0.1	0.0	0.1	0.1	0.1	1.8	2.3
Org N	mg/l	-	-	3.8	3.8	2.6	2.8	2.9	2.4	-	-	-
NO_3-N	mg/l	-	-	0.8	0.8	0.2	0.2	0.4	0.4	0.0	-	2.6
TN	mg/l	-	-	4.7	4.7	2.9	3.0	3.4	2.9	-	-	-
Ortho P	mg/l	-	-	6.8	6.8	5.3	4.4	5.4	5.6	0.0	5.1	16.7
Total P	mg/l	-	-	7.1	7.1	5.5	4.7	5.7	5.7	0.1	5.1	16.8
Temp	°C	-	-	12.	-	16.	16.	12.	11.	-	-	-
DO	mg/l	-	-	11.7	-	11.6	12.1	11.8	9.1	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B- 10. Data For Plot Study For 3-15-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
										7.0	
pH	7.1	-	9.2	9.3	9.3	9.6	9.6	8.4	-	10.0	-
EC umho/cm	1090.	-	865.	865.	884.	877.	869.	898.	0.6	704.	1495.
Cl mg/l	-	-	-	-	-	-	-	-	-	-	-
Turbidity ntu	100.	-	69.	70.	37.	36.	46.	11.	0.0	18.1	-
TSS mg/l	128.	-	85.	83.	58.	56.	63.	26.	-	-	-
BOD mg/l	135.	-	24.	25.	21.	25.	25.	13.	0.5	200.	-
COD mg/l	-	-	-	-	-	-	-	-	-	-	-
TKN mg/l	-	-	5.4	5.2	4.9	3.1	3.2	3.2	0.1	2.0	7.4
NH_4-N mg/l	-	-	-	-	-	-	-	-	-	-	-
Org N mg/l	-	-	-	-	-	-	-	-	-	-	-
NO_3-N mg/l	-	-	-	-	-	-	-	-	-	-	-
TN mg/l	-	-	-	-	-	-	-	-	-	-	-
Ortho P mg/l	-	-	-	-	-	-	-	-	-	-	-
Total P mg/l	-	-	6.0	6.4	4.3	3.2	3.6	5.5	0.0	5.0	15.7
Temp °C	-	-	21.	-	23.	24.	23.	20.	-	-	-
DO mg/l	-	-	10.5	-	9.3	9.8	10.6	6.7	-	-	-
Q liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B-11. Data For Plot Study For 4-4-82.

Parameter		Sample										
		Raw	Runoff	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.6	7.9	9.5	9.5	9.2	9.6	9.9	7.5	-	7.0 10.0	-
EC	umho/cm	1175.	977.	940.	930.	948.	933.	912.	938.	0.6	695.	1570.
Cl	mg/l	169.	197.	174.	179.	188.	191.	184.	176	0.0	173.	352.
Turbidity	ntu	42.	4.2	48.	44.	9.6	12.5	16.5	6.3	0.0	18.0	-
TSS	mg/l	36.2	9.2	68.5	70.0	18.2	26.1	27.7	12.8	-	-	-
BOD	mg/l	108.	4.5	25.	22.	15.	18.	17.	7.2	0.5	200.	-
COD	mg/l	125.	55.	110.	115.	65.	60.	45.	45.	0.0	510.	-
TKN	mg/l	35.4	1.8	5.6	4.9	2.9	2.5	3.7	2.3	0.2	2.3	6.1
NH_4-N	mg/l	30.1	0.6	0.3	0.3	0.2	0.2	0.2	2.7	0.1	1.9	1.1
Org N	mg/l	5.3	1.2	5.3	4.6	2.7	2.3	3.5	-0.4	-	-	-
NO_3-N	mg/l	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.0	1.7	0.1
TN	mg/l	35.5	1.9	5.7	5.0	3.0	2.6	3.8	2.5	-	-	
Ortho P	mg/l	5.7	1.9	2.8	2.9	5.0	2.3	1.7	5.0	0.0	5.1	7.7
Total P	mg/l	6.0	1.9	5.5	5.4	3.0	2.6	2.2	10.6	0.1	5.0	10.1
Temp	°C	-	-	-	-	23.	23.	22.	23.	-	-	-
DO	mg/l	-	-	-	-	8.4	7.5	8.5	4.7	-	-	-
Q	liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B-12. Data For Plot Study For 4-14-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		8.4	-	8.0	8.0	9.0	9.5	9.6	7.6	-	7.0 10.0	-
EC	umho/cm	983.	-	828.	830.	837.	827.	815.	836.	0.59	710.	1482.
Cl	mg/l	156.	-	150.	146.	178.	166.	155.	151.	0.0	180.	336.
Turbidity	ntu	90.	-	7.0	6.9	3.2	3.8	3.5	1.6	0.0	18.0	-
TSS	mg/l	135.	-	14.	14.	7.6	8.0	6.8	3.4	0.0	-	-
BOD	mg/l	137.	-	13.	10.	7.	8.	7.	3.	0.3	210.	-
COD	mg/l	245.	-	30.	35.	40.	50.	40.	40.	-	480.	80.
TKN	mg/l	25.1	-	3.7	4.0	1.9	1.9	2.0	1.6	0.3	2.3	5.0
NH_4-N	mg/l	19.7	-	1.3	1.3	0.2	0.2	0.1	0.1	0.0	1.9	2.2
Org N	mg/l	5.4	-	2.4	2.7	1.7	1.7	1.9	1.5	-	-	-
NO_3-N	mg/l	0.2	-	0.8	0.8	0.1	0.1	0.2	-	1.0	1.8	
TN	mg/l	25.3	-	4.5	4.8	2.0	2.0	2.2	1.7	-	-	-
Ortho P	mg/l	5.7	-	10.7	11.4	4.3	3.3	6.1	6.7	-	5.0	16.7
Total P	mg/l	7.8	-	6.0	6.0	3.8	3.1	2.8	4.4	0.04	5.0	10.6
Temp	°C	-	-	21.	-	25.	25.	25.	22.	-	-	-
DO	mg/l	-	-	8.2	-	9.6	10.6	10.8	6.5	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-13. Data For Plot Study For 4-20-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	-	7.9	7.9	8.8	9.3	9.2	7.8	-	7.0 10.0	-
EC	umho/cm	1090.	-	910.	910.	904.	882.	887.	894.	0.75	704.	1543.
Cl	mg/l	172.	-	165.	165.	172.	172.	164.	167.	0.0	169.	330.
Turbidity	ntu	130.	-	8.3	8.2	4.8	4.8	5.2	2.0	0.0	17.9	-
TSS	mg/l	125.	-	7.2	7.3	2.5	3.0	3.7	1.4	0.0	-	-
BOD	mg/l	162.	-	11.	9.	8.	8.	9.	6.	0.5	195.	-
COD	mg/l	390.	-	25.	25.	30.	25.	25.	20.	-	480.	70.
TKN	mg/l	28.8	-	4.4	4.4	1.7	1.7	2.1	1.1	0.0	2.0	5.4
NH_4-N	mg/l	13.0	-	2.5	2.4	0.0	0.0	0.0	0.0	-	1.9	3.1
Org N	mg/l	15.8	-	1.9	2.0	1.7	1.7	2.1	1.1	-	-	-
NO_3-N	mg/l	0.1	-	0.3	0.3	0.1	0.2	0.2	0.1	-	1.0	1.4
TN	mg/l	13.1	-	4.7	4.7	1.8	1.9	2.3	1.0	-	-	-
Ortho P	mg/l	9.8	-	9.3	9.3	7.7	7.0	6.8	6.6	-	6.1	16.2
Total P	mg/l	12.3	-	7.4	7.4	4.6	4.0	4.1	4.8	0.0	4.8	12.0
Temp	°C	-	-	24.	-	26.	26.	27.	24.	-	-	-
DO	mg/l	-	-	6.2	-	9.3	10.5	10.6	6.0	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-14. Data For Plot Study For 5-3-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	-	8.7	8.7	9.0	9.1	9.5	7.5	-	7.0 10.0	-
EC	umho/cm	1155.	-	945.	940.	946.	965.	925.	953.	0.62	713.	1595.
Cl	mg/l	183.	-	168.	166.	181.	189.	173.	182.	0.0	171.	341.
Turbidity	ntu	92.	-	28.	27.	9.8	12.2	12.9	3.3	0.0	18.0	-
TSS	mg/l	90.	-	50.	40.	16.	20.	22.	4.2	-	-	-
BOD	mg/l	130.	-	14.	15.	12.	12.	14.	8.	0.5	210.	-
COD	mg/l	360.	-	85.	70.	50.	65.	55.	80.	-	40.	115.
TKN	mg/l	39.8	-	9.9	8.3	3.9	2.9	4.5	2.5	0.3	2.2	8.9
NH_4-N	mg/l	23.0	-	2.4	2.6	0.4	0.4	0.4	0.3	0.2	2.0	3.5
Org N	mg/l	16.8	-	7.5	5.7	3.5	2.5	4.1	2.2	-	-	-
NO_3-N	mg/l	0.1	-	0.2	0.2	0.1	0.1	0.1	0.1	-	0.1	0.1
TN	mg/l	39.9	-	10.1	8.5	4.0	3.0	4.6	2.6	-	-	-
Ortho P	mg/l	8.5	-	6.6	7.4	5.9	4.9	3.2	4.4	-	5.1	11.2
Total P	mg/l	10.4	-	7.6	9.0	4.0	3.8	3.3	4.5	0.05	4.9	12.2
Temp	°C	-	-	23.	-	30.	31.	31.	27.	-	-	-
DO	mg/l	-	-	16.6	-	9.5	10.1	10.8	6.2	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-15. Data For Plot Study For 5-10-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
										7.0	
pH	7.4	-	9.3	9.3	9.7	10.1	10.2	7.6	-	10.0	-
EC umho/cm	1185.	-	984.	984.	942.	935.	950.	995.	1.0	702.	1710.
Cl mg/l	165.	-	168.	169.	178.	174.	173.	174.	0.0	164.	355.
Turbidity ntu	120.	-	54.	55.	11.	14.	15.	3.3	0.0	18.0	-
TSS mg/l	106.	-	63.	64.	13.	15.	17.	4.6	0.0	-	-
BOD mg/l	145.	-	22.	20.	11.	12.	9.	7.	0.7	210.	-
COD mg/l	420.	-	165.	185.	70.	90.	75.	65.	-	575.	200.
TKN mg/l	24.0	-	8.8	9.0	3.7	3.0	4.0	2.0	0.5	5.0	12.3
NH_4-N mg/l	23.0	-	3.3	3.3	0.0	0.0	0.0	0.2	0.0	5.1	8.4
Org N mg/l	1.0	-	5.5	5.7	3.7	3.0	4.0	1.8	-	-	-
NO_3-N mg/l	0.0	-	0.6	0.6	0.1	0.1	0.1	0.0	-	-	1.4
TN mg/l	14.0	-	9.4	9.6	3.8	3.1	4.1	2.0	-	-	-
Ortho P mg/l	5.9	-	4.4	4.4	2.0	1.1	0.7	4.4	-	4.9	9.3
Total P mg/l	10.9	-	7.6	7.6	2.6	1.7	1.6	5.1	0.1	5.0	12.6
Temp °C	-	-	24.	-	34.	34.	34.	30.	-	-	-
DO mg/l	-	-	18.5	-	11.1	12.7	13.1	8.0	-	-	-
Q liters/min	-	-	-	-	45.	45.	42.	38.	-	-	-

Table B-16. Data For Plot Study For 5-18-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	-	9.0	9.0	8.4	8.7	8.7	7.6	-	7.0 10.0	-
EC	umho/cm	1200.	-	1130.	1130.	1180.	1170.	1190.	1160.	1.3	714.	1780.
Cl	mg/l	175.	-	194.	188.	198.	199.	198.	205.	0.0	168.	368.
Turbidity	ntu	120.	-	28.	29.	5.4	7.0	7.1	2.8	0.0	18.0	-
TSS	mg/l	119.	-	34.	33.	6.2	8.4	7.6	4.6	0.0	-	-
BOD	mg/l	140.	-	13.	11.	8.1	8.7	7.6	4.7	0.2	180.	-
COD	mg/l	360.	-	70.	75.	125.	115.	100.	115.	-	505.	115.
TKN	mg/l	34.5	-	10.4	10.2	3.1	3.0	4.1	1.8	0.0	5.0	36.8
NH_4-N	mg/l	11.2	-	7.8	7.6	1.0	1.0	1.6	0.1	0.2	5.3	12.8
Org N	mg/l	23.3	-	2.6	2.6	2.1	2.0	2.5	1.7	-	-	-
NO_3-N	mg/l	0.0	-	0.2	0.2	0.3	0.2	0.4	0.1	-	-	1.2
TN	mg/l	34.5	-	10.6	10.4	3.4	3.2	4.5	1.9	-	-	-
Ortho P	mg/l	7.1	-	5.7	5.7	5.8	4.4	6.0	6.2	-	5.0	10.7
Total P	mg/l	9.8	-	6.7	6.6	6.0	4.6	6.0	6.2	0.0	4.9	11.4
Temp	°C	-	-	27.	-	30.	31.	30.	29.	-	-	-
DO	mg/l	-	-	15.7	-	9.2	9.8	9.4	5.8	-	-	-
Q	liters/min	-	-	-	-	45.	49.	45.	38.	-	-	-

Table B-17. Data For Plot Study For 5-25-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	-	8.4	8.4	8.6	9.2	9.1	7.5	-	7.0 10.0	-
EC	umho/cm	1300.	-	1102.	1100.	1085.	1072.	1065.	1094.	0.58	700.	1755.
Cl	mg/l	200.	-	200.	200.	200.	210.	208.	203.	0.0	160.	369.
Turbidity	ntu	100.	-	29.	28.	11.	12.	14.	4.5	0.0	18.0	-
TSS	mg/l	100.	-	43.	45.	22.	18.	22.	10.	0.2	-	-
BOD	mg/l	125.	-	12.	18.	12.	12.	11.	10.	0.5	200.	-
COD	mg/l	305.	-	70.	85.	65.	65.	65.	60.	-	500.	-
TKN	mg/l	42.5	-	6.1	6.3	3.5	3.2	3.5	2.0	0.1	4.8	11.1
NH_4-N	mg/l	32.6	-	2.2	2.2	0.4	0.3	0.3	0.2	0.0	5.0	7.1
Org N	mg/l	9.9	-	3.9	4.1	3.1	2.9	3.2	1.8	-	-	-
NO_3-N	mg/l	0.0	-	0.2	0.2	0.2	0.1	0.2	0.1	-	1.0	1.0
TN	mg/l	42.5	-	6.3	6.5	3.7	3.3	3.7	2.1	-	-	-
Ortho P	mg/l	6.3	-	6.4	6.4	5.5	3.5	4.3	7.0	-	5.1	11.4
Total P	mg/l	8.3	-	7.8	7.8	6.0	3.8	4.6	7.2	0.0	5.1	-
Temp	°C	-	-	28.	-	32.	34.	33.	31.	-	-	-
DO	mg/l	-	-	12.2	-	10.4	11.5	12.4	8.4	-	-	-
Q	liters/min	-	-	-	-	49.	38.	49.	42.	-	-	-

Table B-18. Data For Plot Study For 6-15-82.

Parameter					Sample						
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.3	-	9.0	9.0	8.0	8.6	8.7	7.3	-	7.0 10.0	-
EC umho/cm	1145.	-	1020.	1016.	1055.	1062.	1082.	1081.	0.5	710.	1670.
Cl mg/l	193.	-	193.	194.	204.	210.	215.	210.	0.0	165.	372.
Turbidity ntu	103.	-	21.	21.	5.2	5.9	4.1	2.5	0.0	18.0	-
TSS mg/l	128.	-	27.	28.	7.6	6.8	4.2	2.8	0.0	-	-
BOD mg/l	135.	-	10.	11.	5.0	5.6	3.1	2.7	0.4	210.	-
COD mg/l	260.	-	45.	45.	45.	40.	45.	55.	0.0	90.	80.
TKN mg/l	23.1	-	3.7	3.6	2.0	1.7	1.2	1.9	.10	3.8	4.1
NH_4-N mg/l	18.8	-	0.2	0.3	0.1	0.0	0.1	0.0	0.0	5.1	5.4
Org N mg/l	4.3	-	3.5	3.3	1.9	1.7	1.1	1.9	-	-	-
NO_3-N mg/l	0.1	-	0.7	0.7	0.1	0.1	0.1	0.1	-	1.0	-
TN mg/l	23.2	-	4.4	4.3	2.1	1.8	1.3	2.0	-	-	-
Ortho P mg/l	5.2	-	4.7	4.7	4.7	3.5	3.8	4.7	-	5.0	9.8
Total P mg/l	7.7	-	5.9	5.9	5.1	3.9	4.3	4.8	0.1	-	11.0
Temp °C	-	-	28.	-	34.	35.	35.	35.	-	-	-
DO mg/l	-	-	14.3	-	7.7	7.6	8.2	6.6	-	-	-
Q liters/min	-	-	-	-	-	-	-	-	-	-	-

Table B-19. Data For Plot Study For 6-22-82.

Parameter						Sample					
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.2	-	7.3	7.3	7.3	7.4	7.5	7.1	-	7.0 10.0	-
EC	umho/cm	1130.	-	1065.	1070.	1077.	1084.	1078.	1056.	0.6	702.	1720.
Cl	mg/l	187.	-	185.	185.	194.	191.	210.	220.	0.0	178.	365.
Turbidity	ntu	110.	-	9.9	10.7	4.0	5.9	5.4	3.1	0.0	18.0	-
TSS	mg/l	143.	-	18.	14.	5.2	6.8	7.0	4.4	0.0	-	-
BOD	mg/l	128.	-	6.0	6.6	2.5	4.9	4.4	3.9	0.2	195.	-
COD	mg/l	285.	-	30.	25.	30.	45.	40.	60.	-	102.	70.
TKN	mg/l	33.5	-	4.8	4.7	1.8	1.7	1.6	1.8	0.2	5.0	9.6
NH_4-N	mg/l	22.7	-	2.5	2.5	0.3	0.4	0.3	0.2	0.1	5.0	7.3
Org N	mg/l	10.8	-	2.3	2.2	1.5	1.3	1.3	1.6	-	-	-
NO_3-N	mg/l	0.2	-	0.6	0.6	0.2	0.3	0.3	0.1	-	1.0	1.6
TN	mg/l	33.7	-	5.4	5.3	2.0	2.0	1.9	1.9	-	-	-
Ortho P	mg/l	5.0	-	6.4	6.4	5.9	6.0	6.2	4.1	-	4.9	11.3
Total P	mg/l	7.0	-	7.4	7.2	6.0	6.2	6.6	4.2	0.1	5.1	14.0
Temp	°C	-	-	29.	-	29.	29.	28.	28.	-	-	-
DO	mg/l	-	-	6.3	-	6.7	6.2	6.1	4.6	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-20. Data For Plot Study For 7-14-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	-	8.9	8.9	7.7	7.9	8.0	7.4	-	7.0 10.0	-
EC	umho/cm	1150.	-	995.	995.	1000.	1005.	1010.	1000.	0.86	720.	1650.
Cl	mg/l	176.	-	192.	192.	195.	190.	192.	187.	0.0	175.	365.
Turbidity	ntu	125.	-	45.	44.	16.	20.	19.	12.	0.0	18.0	-
TSS	mg/l	134.	-	44.	43.	17.	22.	20.	14.	0.0	-	-
BOD	mg/l	150.	-	16.	14.	12.	13.	13.	7.0	0.5	200.	-
COD	mg/l	275.	-	60.	90.	85.	50.	45.	50.	-	-	150.
TKN	mg/l	31.0	-	4.0	-	2.7	2.9	3.6	2.9	0.5	5.2	10.2
NH_4-N	mg/l	20.7	-	0.1	0.1	0.1	0.1	0.1	0.1	-	4.9	5.1
Org N	mg/l	10.3	-	3.9	-	2.6	2.8	3.5	2.8	-	-	-
NO_3-N	mg/l	0.0	-	0.1	0.1	0.1	0.1	0.1	0.1	-	1.0	1.1
TN	mg/l	31.0	-	4.1	-	2.8	3.0	3.7	3.0	-	-	-
Ortho P	mg/l	-	-	3.4	3.4	3.5	3.6	3.7	4.2	-	-	8.2
Total P	mg/l	10.1	-	5.6	5.7	5.0	4.5	4.6	6.4	0.1	4.9	10.5
Temp	°C	-	-	28.	-	31.	32.	30.	34.	-	-	-
DO	mg/l	-	-	10.0	-	7.6	8.0	7.5	6.3	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	30.	-	-	-

Table B-21. Data For Plot Study For 7-27-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.3	-	8.7	8.7	7.6	7.7	7.7	7.2	-	7.0 10.0	-
EC umho/cm	1075.	-	960.	958.	965.	968.	966.	980.	0.8	716.	1605.
Cl mg/l	236.	-	173.	174.	204.	184.	221.	192.	0.0	171.	345.
Turbidity ntu	115.	-	16.	16.	4.3	4.6	4.6	4.2	0.0	18.0	-
TSS mg/l	122.	-	20.	22.	4.6	6.0	5.0	5.2	0.0	-	-
BOD mg/l	113.	-	6.0	5.7	4.5	3.6	3.3	2.1	0.1	195.	-
COD mg/l	140.	-	45.	40.	25.	25.	25.	45.	-	-	90.
TKN mg/l	29.1	-	3.0	3.1	2.5	2.0	2.0	2.2	0.2	5.3	8.3
NH_4-N mg/l	17.9	-	0.2	0.1	0.0	0.0	0.0	0.0	-	5.1	5.3
Org N mg/l	11.2	-	2.8	3.0	2.5	2.0	2.0	2.2	-	-	-
NO_3-N mg/l	0.0	-	0.2	0.2	0.0	0.0	0.0	0.0	0.0	1.0	1.2
TN mg/l	29.1	-	3.2	3.3	2.5	2.0	2.0	2.2	-	-	-
Ortho P mg/l	4.2	-	3.8	4.0	3.7	3.6	3.8	3.2	-	-	8.7
Total P mg/l	6.4	-	5.5	5.1	4.0	4.1	4.2	4.0	0.0	5.0	10.2
Temp °C	-	-	30.	-	31.	32.	31.	23.	-	-	-
DO mg/l	-	-	11.2	-	7.2	7.2	6.8	5.4	-	-	-
Q liters/min	-	-	-	-	49.	49.	49.	30.	-	-	-

Table B-22. Data For Plot Study For 8-10-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.0	-	8.1	8.1	7.3	7.5	7.6	7.2	-	7.0 10.0	-
EC	umho/cm	740.	-	699.	698.	695.	693.	695.	705.	0.5	709.	1395.
Cl	mg/l	110.	-	116.	116.	120.	118.	117.	114.	0.0	171.	302.
Turbidity	ntu	65.	-	13.	13.	4.9	5.8	4.3	2.8	0.0	18.0	-
TSS	mg/l	79.	-	20.	20.	4.6	6.8	5.2	2.4	-	-	-
BOD	mg/l	78.	-	11.	11.	5.1	5.5	4.8	2.4	0.1	205.	-
COD	mg/l	205.	-	20.	45.	35.	35.	30.	25.	-	50.	85.
TKN	mg/l	16.1	-	3.5	3.9	1.8	1.6	1.6	1.3	0.1	4.4	9.1
NH_4-N	mg/l	12.1	-	0.9	0.7	0.0	0.0	0.0	0.0	-	5.2	5.8
Org N	mg/l	4.0	-	2.6	3.2	1.8	1.6	1.6	1.3	-	-	-
NO_3-N	mg/l	0.0	-	0.6	0.6	0.2	0.2	0.2	0.02	0.0	1.0	1.6
TN	mg/l	16.1	-	4.1	4.5	2.0	1.8	1.8	1.5	-	-	-
Ortho P	mg/l	3.4	-	3.8	3.8	3.8	3.6	3.5	4.1	-	-	8.8
Total P	mg/l	5.7	-	4.1	4.1	3.8	3.6	3.5	4.1	0.0	5.0	9.0
Temp	°C	-	-	26.	-	31.	32.	32.	32.	-	-	-
DO	mg/l	-	-	10.	-	6.2	6.2	6.3	5.3	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-23. Data For Plot Study For 8-24-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.2	7.3	7.4	7.4	7.3	7.3	7.6	7.1	-	7.0 10.0	-
EC umho/cm	915.	850.	920.	925.	856.	864.	860.	850.	1.7	714.	1590.
Cl mg/l	133.	138.	147.	147.	155.	149.	157.	148.	0.0	171.	325.
Turbidity ntu	7200.	76.	8.3	8.2	3.8	4.5	4.2	2.5	0.0	18.0	-
TSS mg/l	218.	100.	10.	11.	3.4	3.8	4.2	2.2	0.0	-	-
BOD mg/l	147.	-	6.6	4.2	3.3	3.6	3.3	3.0	0.2	200.	-
COD mg/l	470.	70.	20.	25.	20.	20.	25.	25.	0.0	175.	70.
TKN mg/l	43.9	12.6	11.2	10.8	3.7	3.8	3.0	2.2	0.6	5.4	15.8
NH_4-N mg/l	26.2	5.0	8.2	8.3	1.6	1.7	0.5	0.2	-	4.9	13.5
Org N mg/l	17.7	7.6	3.0	2.5	2.1	2.1	2.5	2.0	-	-	-
NO_3-N mg/l	0.0	-	0.6	0.6	0.2	0.3	0.1	0.0	-	1.0	1.5
TN mg/l	43.9	-	11.8	11.4	3.9	4.1	3.1	2.2	-	-	-
Ortho P mg/l	3.9	6.3	7.9	7.7	5.3	5.7	4.7	4.6	0.0	5.0	12.6
Total P mg/l	7.4	8.3	10.3	9.3	6.0	7.3	7.0	6.5	0.0	5.0	14.9
Temp °C	-	-	27.	-	28.	29.	30.	28.	-	-	-
DO mg/l	-	-	3.3	-	6.3	7.0	8.0	4.5	-	-	-
Q liters/min	-	-	-	-	49.	49.	34.	49.	-	-	-

Table B-24. Data For Plot Study For 10-6-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.3	7.5	7.5	-	7.4	7.6	7.3	-	7.0 10.0	-
EC	umho/cm	994.	1007.	985.	981.	-	879.	938.	958.	0.55	701.	1652.
Cl	mg/l	157.	148.	169.	166.	-	149.	162.	148.	0.0	173.	346.
Turbidity	ntu	110.	100.	18.5	18.5	-	4.4	2.4	10.8	0.0	18.0	-
TSS	mg/l	-	-	-	-	-	-	-	-	-	-	-
BOD	mg/l	144.	106.	5.4	6.9	-	7.2	4.8	16.	0.3	195.	-
COD	mg/l	270.	275.	30.	40.	-	40.	25.	60.	0.0	180.	80.
TKN	mg/l	35.3	33.3	8.4	8.7	-	5.8	3.8	18.5	2.0	7.0	13.5
NH_4-N	mg/l	18.9	21.0	5.1	5.1	-	2.5	1.8	15.0	-	5.3	10.1
Org N	mg/l	16.4	13.3	3.3	3.6	-	3.3	2.0	3.5	-	-	-
NO_3-N	mg/l	0.0	0.0	0.4	0.4.	-	0.0	0.2	0.0	-	1.0	1.4
TN	mg/l	35.3	33.3	8.8	9.1	-	5.8	4.0	18.5	-	-	-
Ortho P	mg/l	5.8	5.0	9.6	9.7	-	7.2	8.2	7.8	0.0	5.0	14.5
Total P	mg/l	7.7	7.5	10.1	10.0	-	8.6	9.2	9.0	0.0	5.0	14.7
Temp	°C	-	-	-	-	-	-	-	-	-	-	-
DO	mg/l	-	-	-	-	-	-	-	-	-	-	-
Q	liters/min	-	-	-	-	-	49.	49.	68.	-	-	-

Table B-25. Data For Plot Study For 10-12-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.3	7.3	7.3	7.3	-	-	7.2	-	7.0 10.0	-
EC	umho/cm	975.	988.	912.	906.	933.	-	-	938.	0.75	703.	1583.
Cl	mg/l	147.	146.	149.	158.	158.	-	-	148.	0.0	176.	316.
Turbidity	ntu	63.	59.	7.2	7.3	4.8	-	-	5.1	0.0	18.0	-
TSS	mg/l	106.	100.	7.8	7.6	2.9	-	-	4.1	-0.2	-	-
BOD	mg/l	99.	90.	4.2	3.9	8.0	-	-	11.	0.4	200.	-
COD	mg/l	810.	270.	20.	10.	50.	-	-	35.	-	230.	65.
TKN	mg/l	29.6	31.4	6.1	6.2	15.8	-	-	16.6	0.1	6.0	11.6
NH_4-N	mg/l	19.5	21.6	4.3	4.5	12.8	-	-	13.2	-	5.0	9.4
Org N	mg/l	10.1	9.8	1.8	1.7	3.0	-	-	3.4	-	-	-
NO_3-N	mg/l	0.0	0.0	0.1	0.1	0.0	-	-	0.0	-	1.0	1.2
TN	mg/l	29.6	31.4	6.2	6.3	15.8	-	-	16.6	-	-	-
Ortho P	mg/l	4.5	4.2	8.1	8.2	4.2	-	-	5.5	0.0	5.0	12.9
Total P	mg/l	6.3	5.8	8.4	8.5	4.5	-	-	5.8	0.1	5.0	13.3
Temp	°C	-	25.	25.	-	26.	-	-	25.	-	-	-
DO	mg/l	-	0.6	2.5	-	4.0	-	-	2.5	-	-	-
Q	liters/min	-	-	-	-	49.	-	-	68.	-	-	-

Table B-26. Data For Plot Study For 10-26-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.3	7.5	7.5	7.3	-	-	7.1	-	7.0 10.0	-
EC	umho/cm	1210.	1190.	1090.	1085.	1085.	-	-	1065.	0.98	718.	1765.
Cl	mg/l	187.	183.	188.	194.	189.	-	-	179.	0.0	177.	373.
Turbidity	ntu	120.	92.	4.2	4.2	9.0	-	-	9.9	0.0	18.0	-
TSS	mg/l	160.	102.	5.6	5.6	5.2	-	-	6.5	-	-	-
BOD	mg/l	138.	93.	4.2	4.2	20.	-	-	21.	0.5	205.	-
COD	mg/l	305.	295.	20.	20.	50.	-	-	50.	-	170.	60.
TKN	mg/l	35.3	34.7	7.7	7.5	14.5	-	-	14.6	0.1	4.9	11.5
NH_4-N	mg/l	21.0	21.6	4.0	4.1	10.4	-	-	11.2	-	5.0	8.9
Org N	mg/l	14.3	13.1	3.7	3.4	4.1	-	-	3.4	-	-	-
NO_3-N	mg/l	0.0	0.0	1.3	1.3	0.3	-	-	0.3	-	1.0	2.2
TN	mg/l	35.3	34.7	9.0	8.8	14.8	-	-	14.9	-	-	-
Ortho P	mg/l	5.5	5.8	5.4	5.5	3.2	-	-	2.7	0.0	5.0	10.2
Total P	mg/l	8.2	8.3	7.4	7.6	3.5	-	-	3.2	0.1	5.0	12.3
Temp	°C	-	22.	18.	-	18.	-	-	18.	-	-	-
DO	mg/l	-	1.3	4.7	-	6.1	-	-	3.2	-	-	-
Q	liters/min	-	-	-	-	49.	-	-	68.	-	-	-

Table B-27. Data For Plot Study For 11-2-82.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.2	7.1	7.2	7.3	7.3	7.4	7.2	-	7.0 10.0	-
EC	umho/cm	1180.	1200.	1100.	1110.	1150.	1155.	1100.	1035.	0.67	713.	1760.
Cl	mg/l	190.	179.	190.	188.	203.	205.	209.	168.	0.0	168.	359.
Turbidity	ntu	105.	120.	4.3	4.2	16.	6.5	11.	14.	0.0	18.0	-
TSS	mg/l	125.	91.	6.4	6.1	12.3	5.7	11.0	10.6	0.0	-	-
BOD	mg/l	87.	105.	1.8	3.0	25.	5.4	4.5	22.	0.9	190.	-
COD	mg/l	360.	310.	30.	30.	95.	50.	45.	85.	-	200.	75.
TKN	mg/l	28.2	30.2	4.7	4.8	15.1	2.9	2.6	11.5	0.2	5.6	10.6
NH_4-N	mg/l	27.5	24.5	3.7	3.6	10.6	1.5	0.6	14.2	-	5.1	8.4
Org N	mg/l	0.7	5.7	1.0	1.2	4.5	1.4	2.0	-2.7	-	-	-
NO_3-N	mg/l	0.0	0.0	0.7	0.7	0.2	0.5	0.5	0.1	-	1.0	1.4
TN	mg/l	28.2	30.2	5.4	5.5	15.3	2.4	3.1	11.6	-	-	-
Ortho P	mg/l	7.4	7.5	8.4	8.4	4.1	6.2	5.8	3.3	-	5.0	13.4
Total P	mg/l	10.2	10.1	8.7	8.8	3.7	6.1	6.4	4.6	0.0	5.0	13.7
Temp	°C	-	25.	21.	-	21.	22.	21.	20.	-	26.	-
DO	mg/l	-	1.0	4.9	-	5.2	6.7	6.4	3.0	-	8.2	-
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-28. Data For Plot Study For 11-16-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.4	7.3	7.5	7.5	7.2	7.6	7.7	7.1	-	7.0 10.0	-
EC umho/cm	1160.	1185.	1075.	1070.	1085.	1120.	1080.	1065.	0.70	730.	1770.
Cl mg/l	177.	195.	192.	191.	183.	212.	201.	178.	0.0	174.	368.
Turbidity ntu	50.	45.	4.5	4.6	4.4	4.2	4.1	5.0	0.0	18.0	-
TSS mg/l	62.	50.	7.2	7.0	3.9	3.5	2.8	3.7	0.0	-	-
BOD mg/l	83.	60.	3.6	2.4	9.1	3.1	2.5	12.	0.2	200.	-
COD mg/l	175.	145.	20.	15.	30.	25.	20.	30.	-	175.	65.
TKN mg/l	25.6	24.9	1.2	2.3	11.8	2.4	1.2	12.0	0.0	5.7	7.9
NH_4-N mg/l	14.4	19.0	0.2	0.1	10.0	0.6	0.1	9.5	-	4.9	5.2
Org N mg/l	11.2	5.9	1.0	2.2	1.8	1.8	1.1	2.5	-	-	-
NO_3-N mg/l	0.4	0.2	3.0	3.0	0.6	1.7	2.2	0.4	-	1.0	4.0
TN mg/l	26.0	25.1	4.2	5.3	12.4	4.1	3.4	12.4	-	-	-
Ortho P mg/l	5.7	6.2	6.8	6.8	3.8	4.5	6.0	4.1	-	5.0	11.8
Total P mg/l	7.9	8.2	7.1	7.2	4.0	4.6	6.1	4.3	0.1	5.1	12.1
Temp °C	-	18.	13.	-	16.	16.	15.	15.	-	23.	-
DO mg/l	-	4.4	10.5	-	6.9	8.8	10.0	3.5	-	8.7	-
Q liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-29. Data For Plot Study For 11-30-82.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.3	7.5	7.5	-	7.7	7.7	7.3	-	7.0 10.0	-
EC	umho/cm	1128.	1160.	1060.	1065.	-	1064.	1064.	1107.	1.7	708.	1726.
Cl	mg/l	189.	189.	198.	196.	-	208.	206.	189.	2.0	171.	377.
Turbidity	ntu	60.	40.	5.0	5.5	-	3.6	5.0	6.1	0.0	18.0	-
TSS	mg/l	83.	60.	8.4	6.2	-	3.7	4.4	5.7	0.0	-	-
BOD	mg/l	102.	90.	2.4	3.6	-	4.0	3.2	13.	0.8	200.	-
COD	mg/l	255.	250.	20.	20.	-	20.	15.	45.	-	195.	70.
TKN	mg/l	28.7	31.1	2.8	2.7	-	1.5	1.2	18.5	0.0	5.3	7.8
NH_4-N	mg/l	18.5	21.2	1.2	1.1	-	0.0	0.0	14.5	-	5.0	5.7
Org N	mg/l	10.5	9.9	1.6	1.6	-	1.5	1.2	4.0	-	-	-
NO_3-N	mg/l	1.7	1.0	1.1	1.1	-	0.3	0.6	0.7	-	1.0	1.9
TN	mg/l	30.4	32.1	3.9	3.8	-	1.8	1.8	19.2	-	-	-
Ortho P	mg/l	5.1	5.2	5.2	5.3	-	5.2	5.2	5.1	-	5.0	10.2
Total P	mg/l	7.8	8.0	7.0	6.9	-	6.0	6.3	5.7	0.1	5.0	12.0
Temp	°C	-	-	20.	-	-	22.	21.	19.	-	23.	-
DO	mg/l	-	-	6.5	-	-	8.2	8.7	2.8	-	8.6	-
Q	liters/min	-	-	-	-	-	49.	49.	68.	-	-	-

Table B-30. Data For Plot Study For 12-14-82.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
										7.0	
pH	7.2	7.2	7.4	7.4	7.4	7.7	7.8	7.1	-	10.0	-
EC umho/cm	940.	942.	810.	810.	868.	800.	795.	855.	0.4	716.	1500.
Cl mg/l	140.	141.	135.	135.	135.	137.	142.	132.	0.0	174.	309.
Turbidity ntu	220.	110.	3.6	3.8	8.0	4.5	6.3	6.7	0.0	18.0	-
TSS mg/l	270.	152.	5.4	5.2	5.7	2.4	3.2	4.0	0.0	-	-
BOD mg/l	156.	100.	2.4	2.3	6.9	1.2	0.8	9.0	0.4	202.	-
COD mg/l	390.	330.	40.	40.	60.	55.	45.	60.	-	190.	90.
TKN mg/l	33.1	26.2	2.0	1.9	11.6	1.0	1.0	11.6	0.0	5.1	7.0
NH_4-N mg/l	15.6	14.7	0.8	0.7	9.4	0.1	0.0	9.2	-	-	5.6
Org N mg/l	17.5	11.5	1.2	1.2	2.2	0.9	1.0	2.4	-	-	-
NO_3-N mg/l	0.4	0.1	2.2	2.2	3.0	1.0	2.0	1.9	-	1.0	3.2
TN mg/l	33.5	26.3	4.2	4.1	14.6	2.0	3.0	13.5	-	-	-
Ortho P mg/l	3.3	3.4	4.5	4.5	2.8	3.2	3.8	2.2	-	5.0	9.5
Total P mg/l	7.3	6.1	4.8	4.7	3.2	3.4	3.9	2.4	0.0	5.0	9.8
Temp °C	-	16.	10.	-	12.	12.	11.	12.	-	18.	-
DO mg/l	-	2.6	9.0	-	8.3	9.8	10.2	4.2	-	9.5	-
Q liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-31. Data For Plot Study For 12-28-82.

Parameter		Sample								
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.4	7.2	8.2	8.2	7.2	7.5	7.6	7.3	-	7.0 10.0	-
EC umho/cm	789.	818.	795.	802.	780.	740.	743.	801.	1.8	713.	1481.
Cl mg/l	174.	174.	171.	171.	183.	172.	173.	171.	0.0	178.	353.
Turbidity ntu	>200.	135.	8.0	8.3	18.7	6.1	8.3	13.5	0.1	18.0	-
TSS mg/l	218.	133.	11.0	13.4	15.1	6.4	8.0	7.4	0.1	-	-
BOD mg/l	155.	128.	7.6	7.4	22.	2.8	3.0	19.	0.2	215.	-
COD mg/l	365.	305.	30.	40.	100.	30.	25.	60.	-	-	75.
TKN mg/l	34.3	35.9	2.7	2.3	9.9	1.8	2.0	13.4	0.6	5.6	-
NH_4-N mg/l	20.3	20.3	0.1	0.0	3.7	0.0	0.0	9.0	-	-	-
Org N mg/l	14.0	15.6	2.6	2.3	6.2	1.8	2.0	4.4	-	-	-
NO_3-N mg/l	0.1	0.0	1.3	1.2	5.0	0.4	0.8	1.5	0.0	1.0	2.2
TN mg/l	34.4	35.9	4.0	3.5	14.9	2.2	2.8	14.9	-	-	-
Ortho P mg/l	5.6	5.6	5.2	5.2	5.5	4.7	5.0	5.7	-	-	10.1
Total P mg/l	7.9	7.9	5.5	5.5	5.8	4.6	5.0	5.9	0.1	5.0	10.5
Temp °C	-	16.	15.	-	14.	16.	15.	14.	-	22.	-
DO mg/l	-	1.7	13.8	-	6.8	10.0	10.2	2.6	-	8.8	-
Q liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-32. Data For Plot Study For 1-11-83.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.4	7.3	7.3	7.3	7.2	7.7	7.8	7.2	-	7.0 10.0	-
EC umho/cm	953.	955.	810.	810.	890.	780.	793.	902.	0.75	729.	1475.
Cl mg/l	142.	143.	136.	135.	147.	137.	138.	143.	0.0	174.	320.
Turbidity ntu	103.	52.	9.9	9.7	7.4	5.3	8.8	7.2	0.0	18.0	-
TSS mg/l	120.	101.	11.4	11.4	4.5	4.3	7.0	4.5	0.0	-	-
BOD mg/l	96.	102.	11.4	8.1	9.1	3.9	5.5	12.8	0.6	205.	-
COD mg/l	220.	190.	35.	35.	40.	30.	30.	45.	-	-	75.
TKN mg/l	29.2	31.7	5.1	5.3	16.1	2.6	3.4	17.5	0.4	5.4	10.3
NH_4-N mg/l	17.5	20.5	2.9	2.9	12.3	1.0	1.6	14.4	-	5.0	7.8
Org N mg/l	11.7	11.2	2.2	2.4	3.8	1.6	1.8	3.1	-	-	-
NO_3-N mg/l	0.4	0.4	3.8	4.0	2.0	3.5	3.6	1.4	0.0	1.0	4.5
TN mg/l	29.6	32.1	8.9	9.3	18.1	6.1	7.0	18.9	-	-	-
Ortho P mg/l	4.2	3.8	4.6	4.6	3.6	3.9	4.4	3.8	-	-	9.7
Total P mg/l	7.1	6.2	5.2	5.3	4.0	4.2	4.6	4.3	0.1	5.1	10.3
Temp °C	-	19.	-	-	15.	15.	13.	14.	-	25.	-
DO mg/l	-	2.4	-	-	7.3	10.3	10.4	3.2	-	8.4	-
Q liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-33. Data For Plot Study For 1-25-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.3	7.4	7.5	-	8.0	8.1	-	-	7.0 10.0	-
EC	umho/cm	1040.	1033.	807.	801.	-	790.	798.	-	0.65	712.	1490.
Cl	mg/l	150.	148.	130.	129.	-	130.	130.	-	0.0	172.	304.
Turbidity	ntu	100.	75.	3.7	3.8	-	3.3	4.5	-	0.0	18.0	-
TSS	mg/l	124.	95.	7.4	7.4	-	3.1	3.9	-	0.0	-	-
BOD	mg/l	83.	82.	4.5	3.6	-	2.0	2.0	-	0.2	190.	-
COD	mg/l	265.	200.	20.	20.	-	15.	15.	-	-	190.	65.
TKN	mg/l	28.3	30.3	1.5	1.4	-	1.0	1.0	-	0.1	5.1	6.5
NH_4-N	mg/l	15.7	18.5	0.0	0.1	-	0.0	0.0	-	-	5.1	4.9
Org N	mg/l	12.6	11.8	1.5	1.3	-	1.0	1.0	-	-	-	-
NO_3-N	mg/l	0.1	0.1	6.3	6.6	-	5.4	6.0	-	-	1.0	6.3
TN	mg/l	28.4	30.4	7.8	8.0	-	6.4	7.0	-	-	-	-
Ortho P	mg/l	4.5	4.2	3.9	3.9	-	3.4	3.7	-	-	5.0	8.8
Total P	mg/l	8.8	7.1	4.1	4.2	-	3.4	3.8	-	0.1	5.0	9.0
Temp	°C	-	18.	11.	-	-	13.	10.	-	-	15.	-
DO	mg/l	-	2.9	10.0	-	-	13.0	12.6	-	-	8.4	-
Q	liters/min	-	-	-	-	-	49.	49.	-	-	-	-

Table B-34. Data For Plot Study For 2-8-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.1	7.1	7.3	7.3	7.3	8.6	8.4	7.1	-	7.0 10.0	-
EC	umho/cm	788.	762.	681.	677.	648.	669.	669.	685.	0.86	720.	1332.
Cl	mg/l	126.	125.	113.	112.	105.	114.	114.	111.	0.0	171.	284.
Turbidity	ntu	55.	65.	4.8	4.8	8.3	4.6	5.2	5.8	0.0	18.0	-
TSS	mg/l	76.	92.	7.2	7.4	5.1	3.4	3.3	4.0	0.0	-	-
BOD	mg/l	59.	36.	3.0	4.0	7.0	2.5	2.7	7.9	0.2	200.	-
COD	mg/l	185.	150.	20.	15.	35.	20.	15.	30.	-	-	70.
TKN	mg/l	21.2	21.0	1.5	1.4	4.8	1.2	1.2	8.9	0.8	5.8	8.8
NH_4-N	mg/l	10.4	11.2	0.0	0.0	2.1	0.1	0.1	7.2	-	5.0	5.4
Org N	mg/l	10.8	9.8	1.5	1.4	2.7	1.1	1.1	1.7	-	-	-
NO_3-N	mg/l	0.2	0.2	5.2	5.6	4.2	4.0	4.7	4.1	-	-	6.6
TN	mg/l	21.4	21.1	6.7	7.0	9.0	5.2	5.9	13.0	-	-	-
Ortho P	mg/l	2.8	2.5	3.9	3.9	2.2	3.3	3.8	2.5	-	5.0	8.8
Total P	mg/l	5.3	4.8	4.1	4.1	2.3	3.4	3.8	2.6	0.1	4.9	8.8
Temp	°C	-	16.	12.	-	15.	16.	11.	10.	-	15.	-
DO	mg/l	-	5.1	10.4	-	8.7	13.1	12.1	5.3	-	10.1	-
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-35. Data For Plot Study For 2-22-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.2	7.2	7.0	7.0	7.3	7.6	7.6	7.1	-	7.0 10.0	-
EC	umho/cm	850.	818.	709.	704.	585.	584.	472.	655.	0.61	719.	1320.
Cl	mg/l	124.	120.	116.	116.	93.	95.	78.	94.	0.0	177.	279.
Turbidity	ntu	110.	85.	4.8	5.0	20.	130.	>200.	14.	0.0	10.0	-
TSS	mg/l	140.	296.	6.8	-	29.	83.	169.	11.	0.0	-	-
BOD	mg/l	75.	57.	2.1	1.8	13.	4.2	4.8	9.6	0.2	195.	-
COD	mg/l	205.	145.	15.	20.	45.	25.	20.	30.	-	-	60.
TKN	mg/l	25.8	23.5	1.6	1.4	9.0	2.0	2.2	12.2	0.6	5.4	6.8
NH_4-N	mg/l	10.4	13.0	0.2	0.3	4.5	0.0	0.0	7.8	-	5.0	5.2
Org N	mg/l	15.4	10.5	1.4	1.1	4.5	2.0	2.2	4.4	-	-	-
NO_3-N	mg/l	0.0	0.0	4.6	4.8	1.3	1.9	1.6	3.3	-	-	5.4
TN	mg/l	25.8	23.5	6.2	6.2	10.3	3.9	3.8	15.5	-	-	-
Ortho P	mg/l	-	-	-	-	-	-	-	-	-	-	-
Total P	mg/l	6.3	5.4	3.8	3.8	1.9	2.8	2.2	3.2	0.0	5.0	8.8
Temp	°C	-	-	-	-	17.	18.	17.	15.	-	18.	-
DO	mg/l	-	-	-	-	7.0	10.9	11.1	3.8	-	9.5	-
Q	liters/min	-	-	-	-	49.	49.	49.	49.	-	-	-

Table B-36. Data For Plot Study For 3-8-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.1	7.1	7.9	7.8	7.0	8.1	8.4	7.1	-	7.0 10.0	-
EC	umho/cm	646.	600.	618.	616.	514.	601.	602.	563.	0.92	710.	1310.
Cl	mg/l	92.	87.	106.	104.	77.	105.	105.	85.	0.0	173.	286.
Turbidity	ntu	120.	80.	10.2	10.5	13.2	12.2	13.2	6.7	0.0	10.0	-
TSS	mg/l	89.	52.	13.4	14.2	4.9	8.1	7.2	2.6	0.0	-	-
BOD	mg/l	63.	33.	8.4	8.4	6.0	4.5	3.5	5.6	0.7	200.	-
COD	mg/l	140.	140.	25.	25.	45.	40.	25.	30.	-	190.	70.
TKN	mg/l	13.7	13.3	1.9	1.8	5.3	2.0	2.1	7.8	0.2	5.6	7.9
NH_4-N	mg/l	6.5	6.5	0.2	0.1	2.6	0.1	0.1	2.8	-	5.0	4.6
Org N	mg/l	7.2	6.8	1.7	1.7	2.7	1.9	2.0	5.0	-	-	-
NO_3-N	mg/l	0.2	0.5	1.5	1.6	0.7	0.2	0.6	1.2	-	-	2.7
TN	mg/l	13.9	13.8	3.4	3.4	6.0	2.2	2.7	9.0	-	-	-
Ortho P	mg/l	2.7	2.6	3.6	3.6	2.8	3.1	3.6	3.8	-	5.0	8.6
Total P	mg/l	5.7	5.1	3.8	3.8	2.9	3.2	3.7	4.0	0.1	5.0	8.8
Temp	°C	-	19.	20.	-	23.	27.	23.	18.	-	23.	-
DO	mg/l	-	5.1	10.4	-	5.6	9.0	9.9	3.2	-	8.5	-
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-37. Data For Plot Study For 3-22-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.1	7.5	7.7	7.6	7.3	7.8	8.0	7.2	-	7.0 10.0	-
EC	umho/cm	555.	581.	590.	590.	550.	588.	578.	581.	0.71	726.	1300.
Cl	mg/l	81.	83.	92.	91.	76.	97.	92.	81.	0.0	177.	272.
Turbidity	ntu	25.	35.	9.5	9.5	12.5	13.0	14.0	5.5	0.0	10.0	-
TSS	mg/l	29.	31.	12.8	11.8	4.3	8.1	7.0	1.8	0.0	-	-
BOD	mg/l	35.	40.	7.8	7.9	5.1	5.2	4.2	5.8	0.2	200.	-
COD	mg/l	55.	65.	5.	15.	60.	20.	20.	15.	-	-	60.
TKN	mg/l	1.47	16.0	2.7	2.6	8.2	2.1	2.2	10.8	0.6	5.6	7.9
NH_4-N	mg/l	6.1	7.5	0.7	0.6	4.0	0.0	0.0	8.0	-	4.9	5.2
Org N	mg/l	8.6	8.5	2.0	2.0	4.2	2.1	2.2	2.8	-	-	-
NO_3-N	mg/l	0.5	0.5	2.4	2.5	1.2	1.0	1.8	1.7	-	-	3.4
TN	mg/l	1.5	16.5	5.1	5.1	9.4	3.1	4.0	12.5	-	-	-
Ortho P	mg/l	1.5	1.8	3.1	3.1	1.3	2.3	2.7	2.6	-	-	7.9
Total P	mg/l	2.1	2.8	3.4	3.5	1.4	2.6	2.8	2.8	0.1	5.0	8.5
Temp	°C	-	15.	14.	-	14.	17.	14.	12.	-	22.	-
DO	mg/l	-	5.5	10.7	9.1	12.2	12.6	4.3	-	8.7	-	5.5
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-38. Data For Plot Study For 4-5-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.2	8.8	8.8	7.1	7.9	8.3	7.1	-	7.0 10.0	-
EC	umho/cm	701.	710.	582.	581.	588.	593.	578.	617.	0.61	703.	1263.
Cl	mg/l	106.	100.	97.	97.	95.	103.	99.	94.	0.0	174.	278.
Turbidity	ntu	53.	40.	17.1	17.4	11.5	18.5	19.5	6.1	0.0	10.0	-
TSS	mg/l	60.	47.0	31.0	31.0	7.1	19.6	20.5	4.1	0.0	-	-
BOD	mg/l	51.	48.	21.	12.	9.4	16.	12.	9.8	0.2	215.	-
COD	mg/l	90.	100.	20.	25.	10.	35.	15.	0.0	-	-	70.
TKN	mg/l	20.7	23.8	4.3	4.8	7.5	4.0	3.5	7.1	0.4	5.4	9.3
NH_4-N	mg/l	10.9	14.1	0.3	0.4	4.4	0.1	0.1	4.9	-	5.0	5.3
Org N	mg/l	9.8	9.7	4.0	4.4	3.1	3.9	3.4	2.2	-	-	-
NO_3-N	mg/l	0.5	0.5	3.0	3.0	1.1	0.8	1.5	2.4	-	-	3.2
TN	mg/l	21.2	24.3	7.3	7.8	8.6	4.8	5.0	9.5	-	-	-
Ortho P	mg/l	2.9	2.8	3.1	3.1	-	2.0	2.6	2.2	-	-	7.9
Total P	mg/l	4.6	4.1	3.8	3.8	1.6	2.5	3.0	2.2	0.0	5.0	8.8
Temp	°C	-	19.	18.	-	17.	20.	20.	15.	-	22.	-
DO	mg/l	-	3.7	14.5	-	7.1	10.0	10.7	4.0	-	8.7	-
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-39. Data For Plot Study For 5-3-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.3	7.5	7.5	6.9	8.7	8.0	7.1	-	7.0 10.0	-
EC	umho/cm	681.	692.	640.	642.	610.	632.	639.	640.	0.66	709.	1315.
Cl	mg/l	106.	104.	107.	110.	110.	111.	109.	110.	0.0	172.	284.
Turbidity	ntu	45.	40.	8.4	8.4	14.5	12.0	18.0	5.7	0.0	10.0	-
TSS	mg/l	51.	34.	10.6	10.6	8.0	6.8	13.3	3.7	0.0	-	-
BOD	mg/l	51.	44.	7.2	6.0	7.4	3.9	4.8	6.0	0.4	210.	-
COD	mg/l	120.	90.	20.	20.	40.	30.	30.	35.	-	-	70.
TKN	mg/l	13.3	7.6	1.9	2.1	4.4	1.4	0.7	4.1	0.1	9.8	6.9
NH_4-N	mg/l	8.7	9.5	1.1	1.0	3.0	0.1	0.0	2.7	-	10.1	6.0
Org N	mg/l	4.6	-1.9	0.8	1.1	1.4	1.3	0.7	1.4	-	-	-
NO_3-N	mg/l	0.3	0.3	2.1	2.1	0.6	0.2	0.6	2.2	-	-	3.1
TN	mg/l	13.6	7.9	4.0	4.2	5.0	1.6	1.3	6.3	-	-	-
Ortho P	mg/l	2.6	2.7	4.2	4.1	2.0	2.4	3.3	4.6	-	5.0	9.1
Total P	mg/l	5.5	5.5	4.5	4.7	4.3	2.3	3.5	-	0.0	5.0	9.6
Temp	°C	-	-	23.	-	22.	26.	26.	21.	-	-	-
DO	mg/l	-	-	7.5	-	5.9	9.2	8.1	3.1	-	-	-
Q	liters/min	-	-	-	-	49.	49.	49.	68.	-	-	-

Table B-40. Data For Plot Study For 5-17-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.3	8.7	8.7	7.2	9.0	8.7	6.9	-	7.0 10.0	-
EC	umho/cm	906.	915.	820.	821.	793.	785.	795.	836.	0.40	702.	1492.
Cl	mg/l	149.	146.	149.	149.	144.	149.	146.	139.	0.0	173.	337.
Turbidity	ntu	120.	66.	18.2	18.5	14.9	8.7	12.3	7.4	0.0	10.0	-
TSS	mg/l	124.	81.	34.2	34.5	8.5	6.5	8.5	6.0	0.0	-	-
BOD	mg/l	98.	95.	15.6	15.2	12.0	6.3	4.6	16.4	0.3	200.	-
COD	mg/l	265.	200.	60.	60.	40.	40.	95.	50.	-	-	105.
TKN	mg/l	17.6	17.7	4.9	4.8	8.5	2.4	1.8	6.0	0.1	9.8	9.7
NH_4-N	mg/l	9.6	11.8	1.7	1.8	5.8	0.2	0.1	3.7	-	9.0	6.0
Org N	mg/l	8.0	5.9	3.2	3.0	2.7	2.2	1.9	2.3	-	-	-
NO_3-N	mg/l	0.1	0.1	0.1	0.1	0.6	0.0	0.0	0.2	-	-	0.7
TN	mg/l	17.7	17.8	5.0	4.9	9.1	2.4	1.8	6.2	-	-	-
Ortho P	mg/l	4.6	5.5	5.5	5.4	4.2	2.2	3.5	2.0	-	5.0	10.7
Total P	mg/l	6.8	6.2	5.8	5.8	4.3	2.3	3.7	2.2	0.0	10.0	10.5
Temp	°C	-	24.	24.	-	24.	34.	34.	24.	-	-	-
DO	mg/l	-	1.9	15.9	-	4.6	8.3	9.3	2.4	-	-	-
Q	liters/min	-	-	-	-	47.	49.	49.	47.	-	-	-

Table B-41. Data For Plot Study For 5-31-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.3	7.3	8.9	8.9	7.0	7.5	7.9	7.2	-	7.0 10.0	-
EC	umho/cm	1001.	1013.	889.	912.	890.	918.	918.	915.	1.4	705.	1537.
Cl	mg/l	175.	169.	171.	171.	176.	175.	174.	163.	0.0	175.	353.
Turbidity	ntu	110.	65.	24.	26.	9.6	13.8	17.4	8.2	0.0	10.0	-
TSS	mg/l	97.	75.	54.4	54.0	6.0	11.4	12.0	9.3	0.0	-	-
BOD	mg/l	93.	69.	34.	-	10.2	5.6	5.0	14.8	0.0	185.	-
COD	mg/l	165.	190.	130.	125.	65.	55.	50.	60.	-	-	160.
TKN	mg/l	19.4	23.5	6.5	6.1	6.0	2.4	1.8	10.0	0.3	10.2	11.0
NH_4-N	mg/l	13.2	17.2	1.6	0.9	3.8	0.4	0.1	7.5	-	4.9	5.7
Org N	mg/l	6.2	6.3	4.9	5.2	2.2	2.0	1.7	2.5	-	-	-
NO_3-N	mg/l	0.2	0.0	0.2	0.2	0.9	0.2	0.2	1.0	-	-	0.9
TN	mg/l	19.6	23.5	6.7	6.3	6.9	2.6	2.0	11.0	-	-	-
Ortho P	mg/l	4.0	4.1	5.4	5.4	2.0	4.2	4.7	4.4	-	5.0	10.4
Total P	mg/l	6.2	5.7	6.2	6.3	2.1	4.6	5.1	4.0	-	5.0	11.3
Temp	°C	-	-	-	-	22.	28.	28.	23.	-	26.	-
DO	mg/l	-	-	-	-	5.4	7.9	8.4	2.9	-	8.1	-
Q	liters/min	-	-	-	-	34.	49.	49.	34.	-	-	-

Table B-42. Data For Plot Study For 6-14-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.2	7.2	8.7	8.7	6.9	7.8	8.6	7.3	-	7.0 10.0	-
EC	umho/cm	1056.	1042.	859.	856.	1020.	880.	862.	1021.	0.88	700.	1510.
Cl	mg/l	190.	175.	161.	162.	193.	174.	169.	183.	0.0	175.	336.
Turbidity	ntu	>200.	172.	34.	34.	5.1	2.4	2.7	7.1	0.0	10.0	-
TSS	mg/l	195.	114.	37.2	39.6	3.2	16.5	14.8	4.3	0.0	-	-
BOD	mg/l	123.	99.	28.	27.	4.8	8.6	7.8	10.2	0.3	200.	-
COD	mg/l	155.	110.	70.	60.	40.	50.	40.	45.	-	-	100.
TKN	mg/l	23.7	23.4	4.4	4.3	9.4	2.4	2.2	14.8	0.2	10.1	8.9
NH_4-N	mg/l	17.2	17.7	0.9	0.9	8.2	0.2	0.2	14.6	-	4.9	6.1
Org N	mg/l	6.5	5.4	3.5	3.2	1.2	2.2	2.0	0.2	-	-	-
NO_3-N	mg/l	0.0	0.0	0.1	0.1	0.2	0.0	0.0	0.2	-	-	1.0
TN	mg/l	23.7	23.4	4.5	4.4	9.6	2.4	2.2	15.0	-	-	-
Ortho P	mg/l	5.7	5.1	4.1	4.2	4.7	3.5	3.4	6.1	-	-	9.3
Total P	mg/l	8.2	7.8	5.6	5.8	4.8	3.9	3.5	6.4	0.1	5.1	10.9
Temp	°C	-	-	26.	-	23.	32.	32.	24.	-	26.	-
DO	mg/l	-	-	10.5	-	3.3	6.9	9.0	1.4	-	9.1	-
Q	liters/min	-	-	-	-	55.	49.	49.	55.	-	-	-

Table B-43. Data For Plot Study For 7-5-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.1	7.1	7.7	7.7	6.7	-	-	7.0	-	7.0 10.0	-
EC	umho/cm	881.	866.	720.	715.	775.	-	-	718.	1.5	688.	1390.
Cl	mg/l	-	133.	120.	120.	142.	-	-	117.	-	172.	298.
Turbidity	ntu	-	-	-	-	-	-	-	-	-	-	-
TSS	mg/l	-	100.	27.8	28.2	7.0	-	-	6.3	0.0	-	-
BOD	mg/l	101.	74.	12.	12.	9.4	-	-	12.	0.3	205.	-
COD	mg/l	205.	180.	60.	60.	60.	-	-	55.	-	-	100.
TKN	mg/l	15.6	16.0	5.6	5.8	4.2	-	-	5.7	0.2	10.3	10.1
NH_4-N	mg/l	11.5	11.8	3.0	2.9	1.4	-	-	4.7	-	5.6	8.2
Org N	mg/l	4.1	4.2	2.6	2.9	2.8	-	-	1.0	-	-	-
NO_3-N	mg/l	0.2	0.0	0.2	0.2	1.3	-	-	0.8	-	-	0.9
TN	mg/l	15.8	16.0	5.8	6.0	5.5	-	-	6.5	-	-	-
Ortho P	mg/l	3.5	4.0	4.6	4.6	1.7	-	-	3.2	-	-	9.6
Total P	mg/l	5.5	5.8	5.1	5.1	2.0	-	-	3.7	0.1	5.1	10.1
Temp	°C	26.	27.	31.	-	25.	-	-	25.	-	-	-
DO	mg/l	0.4	0.5	7.2	-	3.5	-	-	2.8	-	-	-
Q	liters/min	-	-	-	-	34.	-	-	34.	-	-	-

Table B-44. Data For Plot Study For 7-19-83.

Parameter	Sample										
	Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH	7.3	7.4	7.6	7.6	7.0	-	-	7.3	-	7.0 10.0	-
EC umho/cm	1125.	1120.	898.	894.	1015.	-	-	955.	0.57	701.	1560.
Cl mg/l	182.	182.	171.	171.	202.	-	-	172.	0.0	174.	351.
Turbidity ntu	110.	80.	16.	16.	5.8	-	-	8.0	0.0	10.0	-
TSS mg/l	170.	77.	18.8	18.5	3.7	-	-	4.3	0.5	-	-
BOD mg/l	152.	128.	18.	14.	4.9	-	-	14.2	0.0	235.	-
COD mg/l	380.	240.	45.	40.	30.	-	-	35.	-	-	90.
TKN mg/l	33.9	28.5	3.7	3.3	4.5	-	-	8.2	0.2	10.2	8.4
NH_4-N mg/l	19.3	19.7	0.6	0.4	3.0	-	-	8.1	-	5.0	5.3
Org N mg/l	24.6	8.8	3.1	2.9	1.5	-	-	0.1	-	-	-
NO_3-N mg/l	0.0	0.0	0.0	0.0.	1.2	-	-	1.5	-	-	1.0
TN mg/l	33.9	28.5	3.7	3.3	5.7	-	-	9.7	-	-	-
Ortho P mg/l	6.0	5.2	4.0	4.0	1.9	-	-	3.1	-	-	9.1
Total P mg/l	9.2	8.0	4.4	4.4	2.7	-	-	3.5	0.1	4.9	9.4
Temp °C	28.	28.	29.	-	26.	-	-	26.	-	-	-
DO mg/l	1.4	2.1	10.0	-	2.9	-	-	2.6	-	-	-
Q liters/min	-	-	-	-	34.	-	-	34.	-	-	-

Table B-45. Data For Plot Study For 8-2-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.5	7.4	7.4	7.4	7.1	7.0	7.1	7.3	-	7.0 10.0	-
EC	umho/cm	1160.	1150.	950.	948.	1080.	885.	900.	1070.	0.80	712.	1630.
Cl	mg/l	184.	188.	177.	173.	187.	152.	147.	173.	0.0	168.	338.
Turbidity	ntu	72.	58.	7.4	7.2	4.0	7.0	3.2	6.2	0.0	10.0	-
TSS	mg/l	67.	72.	6.8	6.8	1.9	3.3	1.1	1.9	0.0	-	-
BOD	mg/l	102.	111.	8.4	7.5	4.0	3.8	1.6	7.8	0.3	190.	-
COD	mg/l	240.	200.	25.	25.	30.	80.	60.	45.	-	-	70.
TKN	mg/l	21.1	21.2	4.8	5.7	7.8	2.4	1.5	12.2	0.2	5.0	9.8
NH_4-N	mg/l	20.5	21.4	3.0	3.1	6.0	0.4	0.3	11.5	-	5.0	7.9
Org N	mg/l	0.6	-0.2	1.8	2.6	1.8	2.0	1.2	0.7	-	-	-
NO_3-N	mg/l	0.1	0.0	0.2	0.2	1.5	0.0	0.0	1.1	-	-	1.1
TN	mg/l	21.2	21.2	5.0	5.9	9.3	2.4	1.5	13.3	-	-	-
Ortho P	mg/l	3.8	3.8	6.4	6.4	3.7	3.2	4.5	5.2	-	-	11.3
Total P	mg/l	6.0	6.0	7.0	7.0	4.7	3.7	4.1	5.5	0.1	5.0	11.9
Temp	°C	-	26.	28.	-	26.	31.	30.	25.	-	27.	-
DO	mg/l	-	0.9	1.6	-	2.5	4.0	6.0	2.6	-	8.0	-
Q	liters/min	-	-	-	-	47.	49.	49.	47.	-	-	-

Table B-46. Data For Plot Study For 8-16-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.4	8.1	8.1	7.1	7.6	7.7	7.3	-	7.0 10.0	-
EC	umho/cm	960.	875.	840.	835.	785.	827.	835.	796.	0.57	708.	1510.
Cl	mg/l	123.	115.	145.	143.	117.	148.	149.	110.	0.0	175.	328.
Turbidity	ntu	85.	62.	17.	18.	4.2	10.	11.	8.6	0.0	10.0	-
TSS	mg/l	152.	77.	9.5	10.1	2.0	13.8	17.0	2.7	0.0	30.	-
BOD	mg/l	132.	84.	11.	10.	3.8	7.6	8.0	12.4	-	135.	-
COD	mg/l	145.	205.	70.	70.	30.	55.	35.	35.	-	-	120.
TKN	mg/l	20.4	20.1	3.1	2.9	5.8	1.9	1.7	11.0	0.1	4.8	7.8
NH_4-N	mg/l	15.6	15.7	0.3	0.4	4.4	0.0	0.0	9.6	-	5.0	5.2
Org N	mg/l	4.8	4.4	2.8	2.5	1.4	1.9	1.7	1.4	-	-	-
NO_3-N	mg/l	0.1	0.0	0.1	0.1	1.5	0.0	0.0	1.2	-	-	1.5
TN	mg/l	20.5	20.1	3.2	3.0	7.3	1.9	1.7	12.2	-	-	-
Ortho P	mg/l	6.7	5.0	5.1	5.1	3.7	3.5	3.6	4.3	-	5.0	10.1
Total P	mg/l	10.5	7.3	5.6	5.7	4.1	3.8	4.0	4.5	0.0	5.0	10.5
Temp	°C	-	27.	27.	-	26.	30.	29.	25.	-	26.	-
DO	mg/l	-	1.8	8.2	-	3.0	6.7	5.8	2.2	-	8.1	-
Q	liters/min	-	-	-	-	47.	49.	49.	47.	-	-	-

Table B-47. Data For Plot Study For 8-29-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.4	7.4	7.6	7.1	7.5	7.6	7.3	-	7.0 10.0	-
EC	umho/cm	1146.	1156.	970.	1175.	980.	978.	1010.	0.65701.		1635.	-
Cl	mg/l	196.	191.	190.	186.	248.	195.	191.	196.	0.0	174.	366.
Turbidity	ntu	115.	95.	19.	19.	5.7	8.5	7.0	5.8	0.0	10.0	-
TSS	mg/l	142.	101.	18.4	18.4	4.8	8.1	7.4	3.0	0.0	30.	-
BOD	mg/l	131.	117.	7.8	7.8	2.7	2.9	3.0	8.8	0.6	78.	-
COD	mg/l	315.	270.	80.	70.	75.	45.	50.	55.	-	-	165.
TKN	mg/l	26.8	26.6	3.5	3.1	3.4	1.8	1.7	6.3	0.6	5.0	8.0
NH_4-N	mg/l	20.0	21.7	0.8	0.4	0.7	0.0	0.0	3.8	-	5.0	5.6
Org N	mg/l	6.8	4.9	2.7	2.4	2.7	1.8	1.7	2.5	-	-	-
NO_3-N	mg/l	0.0	0.0	0.0	0.0	2.8	0.0	0.0	3.2	-	-	2.0
TN	mg/l	26.8	26.6	3.5	3.1	6.2	1.8	1.7	9.5	-	-	-
Ortho P	mg/l	6.1	6.3	5.3	5.3	2.8	4.0	4.4	4.4	-	-	10.0
Total P	mg/l	9.4	8.9	5.5	5.5	2.9	4.1	4.4	4.4	0.1	5.0	10.5
Temp	°C	-	29.	29.	28.	31.	30.	25.	-	26.	-	29.
DO	mg/l	-	0.3	6.4	3.4	6.6	5.4	3.0	-	8.1	-	0.3
Q	liters/min	-	-	-	-	25.	49.	49.	25.	-	-	-

Table B-48. Data For Plot Study For 9-13-83.

Parameter		Sample										
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.4	8.0	8.0	7.1	7.4	7.5	7.2	-	7.0 10.0	-
EC	umho/cm	1030.	1028.	1005.	1004.	902.	927.	945.	940.	1.00	707.	1670.
Cl	mg/l	160.	156.	180.	187.	170.	168.	172.	173.	0.0	174.	369.
Turbidity	ntu	60.	62.	20.	20.	4.0	12.8	11.5	4.4	0.0	10.0	-
TSS	mg/l	90.	70.	28.6	29.4	2.7	5.9	4.8	1.4	0.0	31.	-
BOD	mg/l	74.	69.	8.4	8.4	1.6	4.4	3.5	5.6	0.6	195.	-
COD	mg/l	140.		50.	45.	35.	35.	55.	45.	-	-	95.
TKN	mg/l	22.8	24.0	3.4	3.6	2.0	2.0	1.7	3.2	0.2	4.9	8.1
NH_4-N	mg/l	17.2	18.8	0.5	0.3	0.6	0.0	0.0	1.6	-	5.0	5.2
Org N	mg/l	5.6	5.2	2.9	3.3	1.4	2.0	1.7	1.6	-	-	-
NO_3-N	mg/l	0.1	0.0	0.1	0.1	1.4	0.0	0.0	2.0	-	-	1.0
TN	mg/l	22.9	24.0	3.5	3.7	3.4	2.0	1.7	5.2	-	-	-
Ortho P	mg/l	3.2	3.5	6.1	6.1	4.8	5.1	5.2	5.6	-	-	10.9
Total P	mg/l	4.6	4.6	6.5	6.6	4.9	5.2	5.4	5.9	0.0	5.0	11.4
Temp	°C	-	-	25.	-	25.	25.	25.	24.	-	25.	-
DO	mg/l	-	-	11.6	-	3.8	5.8	5.7	3.6	-	8.4	-
Q	liters/min	-	-	-	-	25.	49.	49.	25.	-	-	-

Table B-49. Data For Plot Study For 11-8-83.

Parameter		Sample									
		Raw	Pri	Pd	Pd	1	2	3	4	Blk	Std	Spike
pH		7.4	7.4	8.0	8.0	-	7.7	7.6	7.3	-	7.0 10.0	-
EC	umho/cm	1145.	1180.	1100.	1100.	-	1100.	1110.	1110.	0.82	710.	1780.
Cl	mg/l	190.	193.	198.	208.	-	225.	198.	199.	0.0	176.	375.
Turbidity	ntu	49.	46.	11.5	11.7	-	4.1	5.6	9.2	0.0	10.0	-
TSS	mg/l	76.	70.	15.0	14.8	-	4.0	6.2	4.5	0.0	30.	-
BOD	mg/l	80.	74.	6.0	6.6	-	3.5	3.3	11.6	0.7	205	-
COD	mg/l	215.	175.	45.	45.	-	50.	30.	50.	-	-	90.
TKN	mg/l	22.3	24.5	2.6	2.4	-	1.5	1.4	11.8	0.1	5.1	7.3
NH_4-N	mg/l	19.8	19.8	0.2	0.0	-	0.0	0.0	9.7	-	-	4.8
Org N	mg/l	2.5	4.7	2.4	2.4	-	1.5	1.4	2.1	-	-	-
NO_3-N	mg/l	0.5	0.2	0.5	0.5	-	0.0	0.1	2.7	-	-	1.6
TN	mg/l	22.8	24.7	3.1	2.9	-	1.5	1.5	14.5	-	-	-
Ortho P	mg/l	5.3	5.6	7.7	7.7	-	6.2	6.8	5.1	-	-	12.7
Total P	mg/l	6.7	7.0	7.7	7.7	-	6.1	6.8	5.1	0.0	4.9	12.6
Temp	°C	-	-	17.	-	-	17.	17.	18.	-	-	-
DO	mg/l	-	-	13.7	-	-	7.7	8.1	2.8	-	-	-
Q	liters/min	-	-	-	-	-	49.	49.	66.	-	-	-

APPENDIX C

DATA FOR RESIDENCE TIME STUDY

Table C-1. Residence Time Study At Q = 25 liters/min.

Time Min	Cl Off mg/l	Time Min	Cl Off mg/l	Time Min	Cl Off mg/l	Time Min	Cl Off mg/l
0	0	155	307	310	143	465	43
5	0	160	297	315	141	470	40
10	0	165	287	320	138	475	37
15	0	170	280	325	134	480	34
20	0	175	278	330	131	485	31
25	0	180	263	335	127	490	28
30	0	185	253	340	123	495	26
35	0	190	242	345	119	500	24
40	0	195	237	350	115	505	22
45	0	200	232	355	111	510	20
50	0	205	228	360	107	515	18
55	0	210	224	365	103	520	16
60	0	215	221	370	100	525	14
65	0	220	213	375	97	530	12
70	27	225	213	380	94	535	10
75	67	230	208	385	91	540	8
80	119	235	203	390	88	545	6
85	163	240	195	395	85	550	4
90	208	245	193	400	82	555	2
95	248	250	187	405	79		
100	279	255	184	410	76		
105	301	260	180	415	73		
110	316	265	175	420	70		
115	327	270	171	425	67		
120	331	275	166	430	64		
125	333	280	162	435	61		
130	332	285	157	440	58		
135	328	290	153	445	55		
140	324	295	151	450	52		
145	320	300	148	455	49		
150	313	305	146	460	46		

Table C-2. Residence Time Study At Q = 34 liters/min.

Time		Cl		Time		Cl	
Min	Off mg/l	On mg/l	Off Adj mg/l	Min	Off mg/l	On mg/l	Off Adj mg/l
0	151		0	315	199		33
5	151	155	0	325	200		31
15	151		0	335	199	176	28
25	151		0	345	197		26
35	151	158	0	355	196		25
45	149		0	365	195	173	24
55	168		18	375	193		21
65	273	155	121	385	191		18
75	323		171	395	189	171	15
85	354		202	405	195		22
95	371	154	219	415	191		17
105	361		208	425	186	176	11
115	346		192	435	186		11
125	328	155	173	445	185		10
135	309		154	455	183	177	8
145	292		137	465	186		9
155	280	164	124	475	182		6
165	267		110	485	181	177	4
175	255		98				
185	246	170	89				
195	240		84				
205	234		79				
215	228	170	73				
225	224		69				
235	222		67				
245	218	173	63				
255	215		60				
265	212		57				
275	211	171	56				
285	207		50				
295	205		45				
305	204	166	39				

Table C-3. Residence Time Study At Q = 47 liters/min.

Time Min	EC Off µmho	Time Min	EC Off µmho
0	0	160	86
5	0	165	82
10	0	170	79
15	0	175	76
20	0	180	73
25	0	185	70
30	0	190	67
35	0	195	64
40	0	200	61
45	17	205	58
50	60	210	55
55	123	215	52
60	165	220	49
65	184	225	46
70	193	230	43
75	195	235	40
80	193	240	37
85	189	245	34
90	184	250	31
95	177	255	28
100	169	260	26
105	159	265	24
110	149	270	22
115	139	175	20
120	128	280	18
125	122	285	16
130	116	290	14
135	109	295	12
140	102	300	10
145	98	305	8
150	94	310	6
155	90	315	4

Table C-4. Residence Time Study At Q = 55 liters/min.

Time		Cl		Time		Cl	
Min	Off mg/l	On mg/l	Off Adj mg/l	Min	Off mg/l	On mg/l	Off Adj mg/l
0	106	106	0	160	153	127	26
5	104	106	0	165	149	126	23
10	104	106	0	170	145	125	20
15	106	106	0	175	146	123	23
20	106	106	0	180	146	122	24
25	102	106	0	185	146	120	26
30	102	106	0	190	144	119	25
35	101	106	0	195	140	121	19
40	104	106	0	200	141	123	18
45	123	106	17	205	139	125	12
50	155	106	49	210	140	127	13
55	200	107	93	215	139	129	10
60	239	107	132	220	140	132	8
65	263	108	155	225	140	131	9
70	267	108	159	230	139	131	8
75	255	109	146	235	140	131	9
80	247	110	137	240	141	131	10
85	240	111	129	245	138	131	7
90	228	112	116	250	139	131	6
95	215	112	103	255	136	131	5
100	204	113	91	260	134	131	3
105	192	113	79	265	133	131	2
110	186	113	73	270	134	131	3
115	180	113	67	275	133	131	2
120	171	113	58	280	132	131	1
125	166	113	53	285	133	130	3
130	164	113	51	290	132	129	3
135	161	115	46	295	130	128	2
140	158	117	41				
145	167	119	38				
150	155	121	34				
155	151	124	27				

Table C-5. Residence Time Study At Q = 75 liters/min.

Time		EC		Time		EC	
Min	Off µmho	On µmho	Off Adj µmho	Min	Off µmho	On µmho	Off Adj µmho
0	790	839	0	155	857	864	36
5	794	"	4	160	855	867	33
10	801	"	11	165	853	"	28
15	805	"	15	170	853	"	25
20	806	"	16	175	852	881	21
25	810	"	20	180	852	"	18
30	810	"	20	185	852	"	16
35	823	"	33	190	852	894	13
40	870	"	80				
45	940	"	150				
50	1018	816	228				
55	1060	"	270				
60	1078	"	288				
65	1068	818	278				
70	1042	"	252				
75	1020	"	230				
80	995	"	205				
85	974	"	184				
90	955	"	164				
95	935	830	143				
100	921	"	126				
105	907	"	110				
110	900	"	100				
115	890	"	88				
120	882	"	78				
125	875	"	69				
130	875	860	69				
135	870	"	63				
140	865	"	57				
145	861	864	52				
150	860	"	46				

APPENDIX D

DATA FOR QUALITY ASSURANCE

Table D- 1. Quality Assurance Data For Cl.

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	99	100	99.0	187	175	106.9
1-19	2	176	175	100.6	185	"	105.7
1-25	3	178	"	101.7	181	"	103.4
2-1	4	177	"	101.1	171	"	97.7
2-8	5	173	"	98.9	179	"	102.3
2-15	6	175	"	100.0	170	"	97.1
2-22	7	172	"	98.3	184	"	105.1
3-8	8	173	"	98.9	163	"	93.1
4-4	9	173	"	98.9	176	"	100.6
4-14	10	180	"	102.9	188	"	107.4
4-20	11	169	"	96.6	165	"	94.3
4-26	12	169	"	96.6	168	"	96.0
5-3	13	171	"	97.7	174	"	99.4
5-10	14	164	"	93.7	187	"	106.9
5-18	15	168	"	96.0	177	"	101.1
5-25	16	160	"	91.4	169	"	96.6
6-15	17	165	"	94.3	178	"	101.7
6-22	18	178	"	101.7	180	"	102.9
7-14	19	175	"	100.0	173	"	98.9
7-27	20	171	"	97.7	172	"	98.3
8-10	21	171	"	97.7	186	"	106.3
8-24	22	171	"	97.7	178	"	101.7
10-6	23	173	"	98.9	179	"	102.3
10-12	24	176	"	100.6	162	"	92.6
10-26	25	177	"	101.1	182	"	104.0

(continued)

Table D- 1. Quality Assurance Data For Cl (cont'd.).

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	168	175	96.0	170	175	97.1
11-16	27	174	"	99.4	176	"	100.6
11-30	28	171	"	97.7	180	"	102.9
12-14	29	174	"	99.4	174	"	99.4
12-28	30	178	"	101.7	182	"	104.0
1-11-83	31	174	"	99.4	185	"	105.7
1-25	32	172	"	98.3	174	"	99.4
2-8	33	171	"	97.7	173	"	98.9
2-21	34	177	"	101.1	163	"	93.1
3-8	35	173	"	98.9	181	"	103.4
3-22	36	177	"	101.1	180	"	102.9
4-5	37	174	"	99.4	181	"	103.4
5-3	38	172	"	98.3	171	"	97.7
5-17	390	173	"	98.9	188	"	107.4
5-31	40	175	"	100.0	182	"	104.0
6-14	41	175	"	100.0	175	"	100.0
7-5	42	172	"	98.3	178	"	101.7
7-19	43	174	"	99.4	180	"	102.9
8-2	44	168	"	96.0	163	"	93.1
8-16	45	175	"	100.0	184	"	105.1
8-29	46	174	"	99.4	178	"	101.7
9-13	47	174	"	99.4	185	"	105.7
11-8	48	176	"	100.6	172	"	98.3
Avg.				98.8			101.1
Std. dev.				± 2.2			± 4.1

Table D- 2. Quality Assurance Data For BOD And COD.

Date	Sample	BOD			COD		
		Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	-	-	-	-	-	-
1-19	2	-	-	-	50	50	100
1-25	3	-	-	-	35	"	70
2-8	4	-	-	-	30	"	60
2-15	5	-	-	-	50	"	100
2-22	6	-	-	-	80	"	160
3-8	7	228	200	114	50	"	100
3-15	8	200	"	100	-	"	-
4-4	9	200	"	100	-	"	-
4-14	10	210	"	105	50	"	100
4-20	11	195	"	98	45	"	90
4-26	12	195	"	98	65	"	130
5-3	13	210	"	105	40	"	80
5-10	14	210	"	105	45	"	90
5-18	15	180	"	90	50	"	100
5-25	16	200	"	100	-	"	-
6-15	17	210	"	105	40	"	80
6-22	18	195	"	98	40	"	80
7-14	19	200	"	100	75	"	150
7-25	20	195	"	98	50	"	100
8-10	21	205	"	102	50	"	100
8-24	22	200	"	100	50	"	100
10-6	23	195	"	98	45	"	90
10-12	24	200	"	100	50	"	100
10-26	25	205	"	102	40	"	80

(continued)

Table D- 2. Quality Assurance Data For BOD And COD (cont'd).

Date	Sample	BOD			COD		
		Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	190	200	95	45	50	90
11-16	27	200	"	100	50	"	100
11-30	28	200	"	100	50	"	100
12-14	29	202	"	101	50	"	100
12-28	30	215	"	108	40	"	80
1-11-83	31	205	"	102	40	"	80
1-25	32	190	"	95	45	"	90
2-8	33	200	"	100	50	"	100
2-22	34	195	"	98	45	"	90
3-8	35	200	"	100	45	"	90
3-22	36	300	"	100	50	"	100
4-5	37	215	"	108	50	"	100
5-3	38	210	"	105	50	"	100
5-17	39	200	"	100	45	"	90
5-31	40	185	"	92	40	"	80
6-14	41	200	"	100	40	"	80
7-5	42	205	"	102	45	"	90
7-19	43	235	"	117	50	"	100
8-2	44	190	"	95	45	"	90
8-16	45	235	"	117	55	"	
8-29	46	78	86	91	95	100	95
9-13	47	195	200	98	50	50	100
11-8	48	205	"	102	50	"	100
Avg.				101			96
Std. dev.				± 6			± 17

Table D- 3. Quality Assurance Data For NH_4-N.

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	-	-	-	1.0	1.0	100
1-19	2	1.0	1.0	100	1.0	"	100
1-25	3	1.0	"	100	1.1	"	100
2-1	4	1.0	"	100	1.0	"	100
2-15	5	1.6	2.0	80	0.8	"	80
2-22	6	2.0	"	100	2.0	2.0	100
3-8	7	1.8	"	90	2.2	"	110
3-15	8	-	-	-	-	-	-
4-4	9	1.9	"	95	0.8	1.0	80
4-14	10	1.9	"	95	0.9	"	90
4-20	11	1.9	"	95	0.7	"	70
4-26	12	2.0	"	100	1.0	"	100
5-3	13	2.0	"	100	1.0	"	100
5-10	14	5.1	5.0	102	5.1	5.0	102
5-18	15	5.3	"	106	5.1	"	102
5-25	16	5.0	"	100	4.9	"	98
6-15	17	5.1	"	102	5.1	"	102
6-22	18	5.0	"	100	4.8	"	96
7-14	19	4.9	"	98	5.0	"	100
7-27	20	5.1	"	102	5.1	"	102
8-10	21	5.2	"	104	5.0	"	100
8-24	22	4.9	"	98	5.2	"	104
10-6	23	5.3	"	106	5.0	"	100
10-12	24	5.0	"	100	5.0	"	100
10-26	25	5.0	"	100	4.9	"	98

(continued)

Table D- 3. Quality Assurance Data For NH_4-N (cont'd.).

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	5.1	5.0	102	4.8	5.0	96
11-16	27	4.9	-	98	5.0	"	100
11-30	28	5.0	"	100	4.6	"	92
12-14	28	-	-	-	4.9	"	98
12-28	30	-	-	-	-	-	-
1-11-83	31	5.0	"	100	4.9	"	98
1-25	32	5.1	"	102	4.9	"	98
2-8	33	5.0	"	100	5.4	"	108
2-22	34	5.0	"	100	5.0	"	100
3-8	35	5.0	"	100	4.5	"	90
3-22	36	4.9	"	98	4.6	"	92
4-5	37	5.0	"	100	5.0	"	100
5-3	38	10.1	10.0	101	5.0	"	100
5-17	39	9.0	"	90	4.3	"	86
5-31	40	4.9	5.0	98	4.5	"	90
6-14	41	4.9	"	98	5.2	"	104
7-5	42	5.6	"	112	5.2	"	104
7-19	43	5.0	"	100	4.8	"	96
8-2	44	5.0	"	100	4.9	"	98
8-16	45	5.0	"	100	4.9	"	98
8-29	46	5.0	"	100	4.8	"	96
9-13	47	5.0	"	100	4.9	"	98
11-8	48	-	-	-	4.8	"	96
Avg.				99			97
Std. dev.				± 5			±7

Table D- 4. Quality Assurance Data For TKN.

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	1.9	2.0	95	0.6	1.0	60
1-19	2	2.2	"	110	2.8	2.0	140
1-25	3	2.0	"	100	1.9	"	95
2-1	4	2.1	"	105	2.1	"	105
2-15	5	2.0	"	100	1.7	"	85
2-22	6	1.7	"	85	1.8	"	90
3-8	7	2.0	"	100	2.2	"	110
3-15	8	2.0	"	100	2.1	"	105
4-4	9	2.3	"	115	0.9	1.0	90
4-14	10	2.3	"	115	1.1	"	110
4-10	11	2.0	"	100	1.0	"	100
4-26	12	1.9	"	95	1.0	"	100
5-3	13	2.2	"	110	1.0	"	100
5-10	14	5.0	5.0	100	3.4	5.0	68
5-18	15	5.0	"	100	5.0	"	100
5-25	16	4.8	"	96	4.9	"	98
6-15	17	-	-	-	-	"	-
6-22	18	5.0	"	100	4.9	"	98
7-14	19	5.2	"	104	6.2	"	124
7-27	20	5.3	"	106	5.2	"	104
8-10	21	4.4	"	88	5.4	"	108
8-24	22	5.4	"	108	4.8	"	96
10-6	23	7.0	"	140	5.0	"	100
10-12	24	6.0	"	120	5.4	"	108
10-26	25	4.9	"	98	3.9	"	78

(continued)

Table D- 4. Quality Assurance Data For TKN (cont'd.).

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	5.6	5.0	112	5.8	5.0	116
11-16	27	5.7	"	114	5.7	"	114
11-30	28	5.3	"	106	5.0	"	100
12-4	29	5.1	"	102	5.0	"	100
12-28	30	5.6	"	112	-	"	
1-11-83	31	5.4	"	108	5.1	"	102
1-25	32	5.1	"	102	5.0	"	100
2-8	33	5.8	"	116	7.3	"	146
2-22	34	5.4	"	108	5.3	"	106
3-8	35	5.6	"	112	6.0	"	120
3-22	36	5.6	"	112	4.8	"	96
4-5	37	5.4	"	108	4.8	"	96
5-3	38	9.8	10.0	98	5.0	"	100
5-17	39	9.8	"	98	5.1	"	102
5-31	40	10.2	"	102	5.0	"	100
6-14	41	10.1	"	101	4.9	"	98
7-5	42	10.3	"	103	4.7	"	94
7-19	43	10.2	"	102	5.1	"	102
8-2	44	5.0	5.0	100	4.9	"	98
8-16	45	4.8	"	96	5.0	"	100
8-29	46	5.7	"	114	4.9	"	98
9-13	47	4.9	"	98	4.8	"	96
11-8	48	5.1	"	102	4.9	"	98
Avg.				105			101
Std. dev.				± 9			± 14

Table D- 5. Quality Assurance Data For NO_3-N And ORTHO P.

Date	Sample		NO_3-N			Ortho P	
		Meas mg/l	Spike mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	1.4	1.0	140	10.1	10.0	101
1-19	2	1.0	"	100	9.6	"	96
1-24	3	2.1	2.0	100	10.2	"	102
2-1	4	1.9	"	95	10.0	"	100
2-15	5	2.2	"	110	10.4	"	104
2-22	6	1.9	"	95	10.8	"	108
2-8	7	1.8	"	90	9.9	"	99
3-15	8	-	-	-	-	-	-
4-4	9	-	-	-	4.9	5.0	98
4-14	10	1.0	1.0	100	5.7	"	114
4-20	11	1.1	"	110	5.8	"	116
4-26	12	0.9	"	90	-	-	-
5-3	13	0.9	"	90	4.2	"	84
5-10	14	0.8	"	80	4.9	"	98
5-18	15	1.0	"	100	5.0	"	100
5-25	16	0.8	"	80	5.0	"	100
6-15	17	-	-	-	5.1	"	102
6-22	18	1.0	"	100	4.9	"	98
7-14	19	1.0	"	100	4.8	"	96
7-27	20	1.0	"	100	4.8	"	96
8-10	21	1.0	"	100	5.0	"	100
8-24	22	0.9	"	90	4.8	"	96
10-6	23	1.0	"	100	4.9	"	98
10-12	24	1.1	"	110	4.8	"	96
10-26	25	0.9	"	90	4.8	"	96

(continued)

Table D- 5. Quality Assurance Data For NO_3-N And ORTHO P (cont'd.).

Date	Sample		NO_3-N			Ortho P	
		Meas mg/l	Spike mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	0.7	1.0	70	5.0	5.0	100
11-16	27	1.0	"	100	5.0	"	100
11-30	28	0.8	"	80	5.0	"	100
12-14	29	1.0	"	100	5.0	"	100
12-28	30	1.0	"	100	4.9	"	98
1-11-83	31	0.6	"	60	5.1	"	102
1-25	32	-	-	-	4.9	"	98
2-8	33	1.2	"	120	4.9	"	98
2-22	34	0.7	"	70	-	"	-
3-8	35	1.1	"	110	5.0	"	100
3-22	36	1.0	"	100	4.8	"	96
4-5	37	-	-	-	4.8	"	96
5-3	38	1.0	"	100	5.0	"	100
5-17	39	0.6	"	60	5.2	"	104
5-31	40	0.7	"	70	5.0	"	100
6-14	41	0.9	"	90	5.1	"	102
7-5	42	0.7	"	70	5.0	"	100
7-19	43	1.0	"	100	5.1	"	102
8-2	44	0.9	"	90	4.9	"	98
8-16	45	1.4	1.5	93	5.0	"	100
8-29	46	2.0	2.0	100	4.7	"	94
9-13	47	0.9	1.0	90	4.8	"	96
11-18	48	0.9	"	90	5.0	"	100
Avg.				94			97
Std. dev.				± 15			± 16

Table D- 6. Quality Assurance Data For Total P.

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
1-12-82	1	5.2	5.0	104	10.1	10.0	101
1-19	2	4.9	"	98	9.5	"	95
1-25	3	5.0	"	100	9.5	"	95
2-1	4	5.1	"	102	9.2	"	92
2-15	5	5.0	"	100	10.0	"	100
2-22	6	5.1	"	102	9.0	"	90
3-8	7	5.1	"	102	9.7	"	97
3-15	8	5.0	"	100	9.5	"	95
4-4	9	5.0	"	100	4.7	5.0	94
4-14	10	5.0	"	100	4.6	"	92
4-20	11	4.8	"	96	4.6	"	92
4-26	12	-	"	-	-	"	-
5-3	13	4.9	"	98	3.9	"	78
5-10	14	5.0	"	100	5.0	"	100
5-18	19	4.9	"	98	4.8	"	96
5-25	16	5.1	"	102	-	"	-
6-15	17	-	"	-	5.1	"	102
6-22	18	5.1	"	102	6.7	"	134
7-14	19	4.9	"	98	4.9	"	98
7-27	20	5.0	"	100	4.9	"	98
8-10	21	5.0	"	100	4.9	"	98
8-24	22	5.0	"	100	5.1	"	102
10-6	23	5.0	"	100	4.7	"	94
10-12	24	5.0	"	100	4.9	"	98
10-26	25	5.0	"	100	4.8	"	96

(continued)

Table D- 6. Quality Assurance Data For Total P (cont'd.).

Date	Sample	Meas mg/l	Std mg/l	Rec %	Meas mg/l	Spike mg/l	Rec %
11-2	26	5.0	5.0	100	5.0	5.0	100
11-16	27	5.1	"	102	5.0	"	100
11-30	28	5.0	"	100	5.0	"	100
12-14	29	5.0	"	100	5.0	"	100
12-28	30	5.0	"	100	5.0	"	100
1-11-83	31	5.1	"	100	5.0	"	100
1-25	32	5.0	"	100	4.9	"	98
2-8	33	4.9	"	98	4.7	"	94
2-22	34	5.0	"	100	5.0	"	100
3-8	35	5.0	"	100	5.0	"	100
3-22	36	5.0	"	100	5.0	"	100
4-5	37	5.0	"	100	5.0	"	100
5-3	38	5.0	"	100	5.0	"	100
5-17	39	10.0	10.0	100	4.7	"	94
5-31	40	5.0	"	100	5.0	"	100
6-14	41	5.1	"	102	5.2	"	104
7-5	42	5.1	"	102	5.0	"	100
7-19	43	4.9	"	98	5.0	"	100
8-2	44	5.0	"	100	4.9	"	98
8-16	45	5.0	"	100	4.9	"	98
8-29	46	5.0	"	100	5.0	"	100
9-13	47	5.0	"	100	4.9	"	98
11-8	48	4.9	"	98	4.9	"	98
Avg.				100			98
Std. dev.				± 1			±7

APPENDIX E

DESCRIPTION OF ANALYTICAL PROCEDURES

pH

Equipment:

Orion 701 meter and 81-02 combination electrode.

Standard:

1 - One buffer tablet for pH 4.0, one for 10.0 in 100 ml DI water.

2 - Or commercially prepared buffer solution.

Calibration of meter:

1 - Place electrode in the standard.

2 - Use stirring bar for good mixing.

3 - Set buffer and temperature knobs until pH = 4.0 and 10.0 are read.

CONDUCTANCE

Equipment:

YSI 32 Field/Laboratory conductance meter.

Procedures:

1 - Probe and thermister are placed in sample.

2 - Proper range is selected that gives reading.

3 - Read blank (DI water).

4 - Read standard (5 mM KCl).

5 - Read spike (Pond + standard).

6 - Read samples.

TURBIDITY

Equipment:

Hach 18900 Ratio Turbidimeter

Calibration:

1 - Set meter to 0 with DI water.

2 -Use 18 NTU standard for calibration.

Testing:

Samples are poured in the cuvette and readings are taken directly.

CHLORIDE

Equipment:

Chloridometer Automatic Titrator (Buchler Instruments, Inc.)

Reagents:

A) Gelatin: Mix 0.63 gm gelatin in 100 ml warm distilled water. (Keep refrigerated until use.)

B) Acetic - nitric acid: Add 25.6 ml nitric acid + 400 ml glacial acetic acid to 1 liter flask. Make up to 1 liter with distilled water.

C) Standards:

1 Prepare stock solution as follows

$$\frac{74.555 \text{ gm KCl/mole}}{35.453 \text{ gm Cl/mole}} = 2.1029 \text{ gm/liter}$$

2 Prepare 10 ppm, 100 ppm from the stock solution.

Procedures:

1 - Add 1 ml of sample.

2 - Add 3 ml of acetic - nitric acid.

3 - Add 4 drops of liquified gelatin.

4 - Set timer to zero.

5 - Turn the titration knob (on the left) to adjust (setting 1). Wait until the D.C. microamp needle stops moving (near zero).

6 - With above mix in the test tube switch to titrate (setting 2). Use medium range.

7 - When the timer stops, read the time in seconds.

8 - Use the linear regression formula

$$Cl = \frac{t-7.0}{0.419}$$

9 - When reporting, use whole numbers.

BOD

Equipment:

Orion 97-08 DO probe.

Reagents:

A) Phosphate buffer solution: Dissolve 8.5 g KH_2PO_4, 21.75 g K_2HPO_4, 33.4 g $Na_2HPO_4 \cdot 7H_2O$, and 1.7 g NH_4Cl in about 500 mL DI water and dilute to 1 L. The pH should be 7.2 without further adjustment. Discard reagent (or any of the following reagents) if there is any sign of biological growth in the stock bottle.

B) Magnesium sulfate solution: Dissolve 22.5 g $MgSO_4 \cdot 7H_2O$ in DI water and dilute to 1 L.

C) Calcium chloride solution: Dissolve 27.5 g $CaCl_2$ in DI water and dilute to 1 L.

D) Ferric chloride solution: Dissolve 0.25 g $FeCl_3 \cdot 6H_2O$ in DI water and dilute to 1 L.

E) Glucose-glutamic acid solution: Dry reagent-grade glucose and reagent-grade glutamic acid at 103°C for 1 hr. Add 150 mg glucose and 150 mg glutamic acid to DI water and dilute to 1 L. Prepare fresh immediately before use.

Dilution water is 1 ml/L of A, B, C, and D added to DI water.

Calibration:

1 - 250 ml of tap water.

2 - Saturate with oxygen by stirring the water rapidly.

3 - Insert probe and allow 1 minute to stabilize.

4 - Using table (solubility of oxygen in fresh water) find the oxygen ppm at the water temperature (20°C) and adjust machine.

BOD (cont'd)

Testing Procedures:

1 - Samples (non-acidified) are diluted to make total volume of 305 ml using dilution water.

2 - Seed is obtained by allowing 100 ml non-acidified raw sewage to settle for 1 hr. in a beaker at 20°C. The supernatant is drawn off for seed and used at the rate of 1 ml/300 ml of sample.

3 - Samples are stirred at 20°C to equilibrate oxygen.

4 - Using the O_2 probe, record the amount of dissolved oxygen.

5 - Standard is 2 ml of Reagent (E) per 100 ml of DI water plus seed.

6 - Pour samples in the special BOD bottles.

7 - Keep samples in the incubator (20°C) for 5 days.

8 - After 5 days, measure the amount of oxygen left.

COD

Equipment:

Hach COD reactor

Reagents:

A) Standard - dry potassium hydrogen phthalate at 120°C to constant weight, dissolve 42.5 mg in 100 ml H_2O for COD of 500 mg O_2/L.

Procedures:

1 - Preheat block to 150°C.
2 - Add 2.0 ml of sample to the Hach vials.
3 - Add 2.0 of DI water for the blank. Spike is 5 ml of stock 500 ppm in 50 ml volumetric + 45 ml of pond sample.
4 - Shake tubes and place in preheated digestor at 150° C and digest for 2 hours.
5 - Wait for tubes to cool after digesting.
6 - Shake tubes and let them sit for 5 mins.
7 - Read loss of Cr^{+6} at 445 nm wave length.
8 - Set 500 ppm standard on 0 absorbance. Read absorbance of 100 and 200 ppm standards and blank.
9 - Graph absorbance vs. concentration.
10 - Read samples and calculate concentrations to nearest 5 mg/l.

AMMONIA-N

Equipment:

Tecator 1002 steam distillation unit

Reagents:

A) Dissolve 0.3819 gm NH_4Cl in DI water and bring to volume in a 1 L volumetric flask. This is a 100 ppm std.

B) Dissolve 10 gm boric acid in 1 liter of DI water.

C) Borate buffer: Add 88 ml of 0.1 N N_aOH solution to 500 ml of 0.025 M sodium tetra borate solution (5.0 gm anhydrous $Na_2B_4O_7$ or 9.5 gm $Na_2B_4O_7 \cdot 10H_2O$ per liter) and dilute to 1 liter.

D) Nessler Reagent: Commercially obtained.

Procedure:

1 - Prepare Tecator distillation unit.

2 - Add 25 ml boric acid to receiver on distillation unit.

3 - Titrate acidified sample on auto-titrator to pH 9.5.

4 - Transfer sample to distillation tube.

5 - Add 5 ml borate buffer to tube.

6 - Steam sample until 75 ml is collected.

7 - Transfer sample to 100 ml volumetric flask, bring to volume and return to flask.

8 - Add 4 ml Nessler Reagent.

9 - Read at 425 nm. in 10-15 minutes.

10 - Blank is deionized water and starting at step 4.

11 - 5 ppm std. is made using boric acid and water.

TOTAL KJELDAHL NITROGEN

Equipment:

Labconco 23000 block digestor and Tecator 1002 steam distillation unit

Reagents:

A) Mercuric sulfate: Dissolve 8.0 gm HgO in 50 ml of Hot 1:4 - H_2SO_4 (10 ml H_2SO_4 + 40 ml DI water) and dilute to 100 ml.

B) Digest solution: Dissolve 133 gm K_2SO_4 in 700 ml DI water and 200 ml of conc. H_2SO_4. Add 25 ml of soln. A and dilute to 1 liter.

C) Boric acid solution: Dissolve 10 gm boric acid in 1 liter of DI water.

D) 25% solution of NaOH.

E) Standard same as for ammonia.

Procedures:

1 - Preheat block to 200°C for 1/2 hr.

2 - 50 ml sample + teflon chips.

3 - 10 ml Kjeldahl digest solution.

4 - For spike add 5 ml - 100 ppm NH_4^+ to 100 ml volumetric and fill to mark with Pd sample.

5 - Heat at 200°C for 1 hr. Then turn up to 350°C for 1 hr.

6 - Let cool 5-10 minutes then add 50 ml DI water.

7 - Prepare Tecator distillation unit.

8 - Place 25 ml boric acid in erlenmeyer receiver flask.

9 - Add NaOH (25%) to digest tube by pulling plunger down once (20 ml).

10 - Pull steam lever down and raise erlenmeyer to up position.

TOTAL KJELDAHL NITROGEN (cont'd)

11 - Collect 75 ml in the erlenmeyer flask.

12 - Raise to 100 ml volumetrically using DI water.

13 - Return sample to flask and add 4 ml Nessler Reagent and mix.

14 - Color should develop 10-15 minutes later.

15 - Read on spectrophotometer at 410 nm.

16 - Counter blank is made by starting at step 8 with an empty digest tube.

17 - Set blank on zero absorbance.

18 - Prepare counter standard of 5 ppm using 25 ml boric acid.

NITRATE - N

Reagents:

A) Sulfuric acid: Add 500 ml Conc. H_2SO_4 to 125 ml DI water.

B) Brucine sulfanilic acid: Dissolve 1 gm brucine sulfate and 0.1 gm sulfanilic acid in 70 ml hot DI water. Add 3 ml Conc. HCl, cool, mix and dilute to 100 ml with DI water. Store in dark bottle at 5°C. Stable for several months.

C) 100 ppm stock solution: Dissolve 0.7218 anhydrous KNO_3 in DI water water and dilute to 1 liter. Preserve with 2 ml chloroform per liter - stable 6 months. Prepare standards of 0.2, 0.4, 0.6, 0.8, 1.0, 1.5 and 2.0 ppm.

D) One boiling water bath and one at 10-15°C.

Procedure:

1 - Adjust pH of sample to approximately 7.

2 - Pipette 10.0 ml of standards and samples into labeled sample tubes in racks. Include an interference control for each sample.

3 - Pipette 10.0 ml of H_2SO_4 (Soln A) into each tube and mix, place in 10°C bath and allow all samples to come to equilibrium (15 minutes).

4 - Add 0.5 ml brucine - sulfanilic acid to each tube, except sample controls and swirl.

5 - Place racks in the 100°C water bath for 25 minutes.

6 - Remove rack and place in cold bath and allow temperature to drop to 20-25°C.

7 - Read at 410 nm.

ORTHO PHOSPHORUS

Reagents:

A) Acid - 11 N H_2SO_4: Slowly add 155 ml Conc. H_2SO_4 to 345 ml DI water.

B) Dissolve 0.100 gm antimony potassium tartrate and 4.0 gm ammonium molybdate in 400 ml DI water; raise to 500 ml with DI water.

C) Dissolve 6.00 gm ascorbic acid in 100 ml DI water.

Procedures:

1 - 2.5 ml sample, DI water for blank; plus 35 ml of DI water.

2 - 1 ml 11 N H_2SO_4 + 4.0 ml Reagent A; mix well.

3 - 2.5 ml ascorbic acid (Reagent B); mix well.

4 - Raise volume to 50 ml with DI water

5 - Color will develop within 10 min.

6 - Read samples at 880 nm.

7 - Set blank (DI water) at 0 absorbance.

8 - Set standard (5 mg/l P) at concentration 5.00 on spectrophotometer.

9 - Record results with one decimal point.

TOTAL PHOSPHORUS

Reagents:

A) Acid - 11 N H_2SO_4: Slowly add 155 ml Conc H_2SO_4 to 345 ml DI water.

B) Dissolve 0.100 gm antimony potassium tartrate and 4.0 gm ammonium molybdate in 400 ml DI water; raise to 500 ml with DI water.

C) Dissolve 6.00 gm ascorbic acid in 100 ml H_2O.

Procedures:

1 - Add 2.5 ml sample, DI water for blank, to digestion tube.

2 - Add 1 ml 11 N H_2SO_4.

3 - Add 0.4 gm ammonium persulfate (use special scoop) to each tube then add 50 ml DI water.

4 - Digest on preheated block at 180°C until volume is reduced to 5-10 ml.

5 - Transfer quantitatively to 50 ml volumetric using two 15 ml aliquots of DI water

6 - Add 4.0 ml Reagent A; mix well.

7 - Add 2.0 ml Reagent B; mix well.

8 - Raise the volume to 50 ml.

9 - Color will develop within 10 mins.

10 - Read at 880 nm.

11 - Set blank and standard as with ortho P.

TOTAL SUSPENDED SOLIDS

Standard: EPA Quality Assurance Standard.

Procedure:

1 - Rinse type A-E glass fiber filters with dionized water, dry in convection oven at 100°C, and place in dessicator for use.

2 - Pre weigh filters on analytical balance to 0.1 mg.

3 - Mix sample and measure out appropriate aliquot. Use 100 ml of standard.

4 - Filter samples, dry in oven at 100°C, and place in desicator.

5 - Weigh filters to nearest 0.1 mg.

6 - Calculate TSS.